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ABSTRACT

The purpose of this study of modern communications technology in education is to present a systematic conceptual approach for analyzing instructional technology, to identify research and development priorities in less developed countries, and to formulate 26 high priority projects to be undertaken in the coming years. Chapter I summarizes the conceptual nature of living systems which is used throughout the document, and Chapter II describes living systems in the educational process. Problems related to the use of instructional technology are presented in Chapter III. Chapter IV presents a research and development chart employing the systems concepts discussed to show the relationships between the 26 high priority research projects, and the projects are outlined in detail in Chapter V. Throughout the study, nontechnical solutions to educational problems are excluded as are country-specified solutions and basic educational research. Emphasis is on both formal and nonformal education. (CH)

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ACADEMY FOR EDUCATIONAL DEVELOPMENT

# RESEARCH AND DEVELOPMENT PRIORITIES IN INSTRUCTIONAL TECHNOLOGIES FOR THE LESS DEVELOPED COUNTRIES

James G. Miller, M. D., Ph. D.

U S DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

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IR 003 478

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We need a fundamentally new strategic approach which breaks the shackles of convention and dares to contemplate innovations of a sort we readily accept in other realms of life but which, for lack of courage or imagination, we have scarcely yet dreamed of in the vital realm of human learning and development.

—Phillip H. Coombs in
The World Educational Crisis

# INTRODUCTION

## 1. The Problem

The purposes of this study are (a) to present a systematic conceptual approach by which to analyze the present state and future potentials of instructional technology; (b) to identify priority areas for research on and development of instructional technologies in less developed countries; and (c) to formulate 26 high priority research or development projects which should be undertaken in the next several years.

Chapter I of this report summarizes the general systems conceptual system which we use throughout this document. Chapter II describes the living systems involved in the educational process. Chapter III discusses problems related to the use of instructional technologies in educational systems. Chapter IV presents in chart form a research and development map employing the systems concepts discussed previously, to show the relationships between 26 high priority research and development projects. Chapter V outlines in detail the research and development projects designed to answer these questions.

In recent years much interest has arisen in the potential use of instructional technology for solving major educational problems. Initially the interest focused on education in established countries. More recently, however, less developed countries have been included. Indeed, their obvious needs, apparently incapable of being met by traditional means, make them more likely than some wealthier nations with less demanding problems to use the instructional technologies. UNESCO, the World Bank, the Agency for International Development, and the Ford Foundation are among the many organizations investing money and effort in research and development in communications technologies.

The appeal of instructional technologies applied to educational problems in developing countries is understandable. The vast scale of their educational problems tends to compel them to explore solutions which are capable of dealing with problems of such magnitude. The urgency of the problems makes them reluctant to accept gradual, incremental changes. Instructional technologies seem to promise approaches that can cope with the scale and urgency of the problems. The studies proposed in this report are directed toward the achievement of useful results within a time frame of five to ten years.

But those who try to use instructional technologies face many problems like the following: (a) Technology in and of itself cannot solve any educational problem. (b) No major improvement in education can come about without reform of the human institutions and procedures involved. (c) Technology brings with it new and poorly understood problems of its own. And (d) technology in both established and less developed countries poses political, social, and cultural issues that make it less than ideal as a solution.

Legislation which has made funds available for research and development in instructional technologies in less developed nations is included under the Foreign Assistance Act of 1970. Under Section 220 of this act the President of the United States is authorized to "carry out programs of peaceful communication." Section 220 specifically emphasizes the importance of assisting less developed countries to make use of communications technologies for educational, health, agricultural, and community development purposes. The Agency for International Development has been encouraged to participate in directing these efforts in the hope that the United States can contribute to the application of available technologies to meet human needs. The kinds of programs which have been foreseen range from providing less developed countries with assistance in research, training, and planning to designing pilot projects in the use of technologies for development purposes.

## 2. The Scope of the Study

The determinants of the scope of this study deserve attention. It has been conducted under contractual constraints and terms of reference which should be recognized by the reader.

### 2.1 Nontechnical solutions to educational problems excluded.

The subject of this study was specifically designated as, "the uses of modern communications technology in education." Communications technology was defined as the means by which messages are communicated, presumably including their presentation, transmission, recording or storing, and delivery or broadcast. The charge to us excluded consideration of the "technology of education" which includes "the systematic application of the resources of scientific knowledge to the process that each individual has to go through in order to acquire and use knowledge."[1] The restricted definition of our task specified in our contract has led us to neglect organizational technology, which is an aspect of the technology of education. Organizational technology, the systematic analysis of the organization of human resources aimed at maximizing the realization of their potential, holds enormous promise for educational systems in developing countries. We believe that research on this in less developed countries is as appropriate as study of communications technologies. It deserves separate detailed attention in some other study.

A good case can be made for restricting this report to the communications technologies. Fundamentally it rests on the argument that, if one is looking for major, rapid improvements in terms of cost-effectiveness, communications technologies hold much more promise for educational systems than organizational technologies which require more gradual implementation of change. Yet we cannot today be at all sure that the cost-effectiveness of any instructional technology is even close to being competitive with reformed human-based teaching systems. Some of the proposed projects in this report are designed to throw light on this issue. The less developed countries have an opportunity and ample incentive to attempt new educational approaches and question some of the institutionalized educational practices of the established Western nations.

### 2.2 Country-specified solutions excluded.

A second contractually determined aspect of this study may also be perceived as a strength, namely its broad scope. The findings of the proposed projects are not expected to be country-specific. The perspective of the study is that of an international agency. It assumes that the educational problems of less developed countries are sufficiently general to permit examination of solutions on a cross-country basis. Before the conclusions of any project we propose can be applied to a specific country, however, they must obviously be reviewed in the light of the particular conditions existing there. For each project, however, we suggest a few countries where AID might appropriately conduct it.

### 2.3 Emphasis on both formal and nonformal education.

The contract also specifies that the proposed projects should deal with both formal and nonformal education. Under the term "education" we include training in everything from voting and citizenship to family planning to agricultural training to traditional primary and secondary education. Throughout this report we dispute the fallacy of assuming that most learning goes on in schools, colleges, and universities. Quite the contrary. Most of it goes on in nonformal situations, outside the official institutions of learning. It has always been so everywhere. Indeed, before 1800 in no country did any but the children of the rich and privileged ever receive any formal education.

It is fashionable today to look to nonformal education as the way to compensate for failure of the traditional school system to meet the needs of the developing countries. This is an inadequate appraisal of the situation. The best strategy for less developed countries is not creation of a second mode of education but rather reform of the entire system. Less developed countries cannot afford to maintain two educational systems simultaneously. The formal system of education absorbs a large part of all such countries' budgets. It is bad management to continue using that money inefficiently while spending further money to develop an alternative system. All modes of education should be viewed as one entity and planning for them should be integrated.

The major shortcoming of nonformal education is that usually it provides inadequate motivation for many to take advantage of it. Currently the formal educational system in less developed countries has almost a monopoly on incentives to learn, i.e., the social status, jobs, and upward mobility it provides. Unless the nonformal system of education also incorporates such incentives, nonformal education will probably never achieve its goals. The instructional technologies which we have selected for particular attention in this study are promising for both nonformal and formal education.

### 2.4 Basic educational research excluded.

Given the maximum five- to ten-year time span over which it is desired that the proposed projects make their impact, most basic educational research is essentially ruled out of consideration. A multitude of basic researches applicable to less developed nations have already been carried out. Most of these investigative efforts are waiting to be applied. If certain specific basic studies relevant to particular cultures or countries need to be carried out as part of a project, that can, of course, be done. Such researches may, however, delay application beyond the specified time limits.

The literature on research about educational technology clearly demonstrates the extreme complexity of the interactions of technological systems and human educational systems. Most research in education attempts to identify, isolate, and evaluate variables that influence teaching and learning. However, in the study of instructional technology, to quote Klapper, "the variables (have) emerged in such a cataract that (the researchers) have almost drowned."[2] The flood of additional variables which must be considered does not seem to be subsiding. This means that, if instructional technology is to be applied in the next decade, practical projects must be undertaken before all the relevant basic researches are completed.

In our review of the literature and our discussions with persons experienced in the field of instructional technology, we discovered few investigations that were immediately policy-relevant. The research projects we are proposing in this report are designed to be policy-relevant. An educational planner needs to have information on the effectiveness of different technologies in solving different problems, information he can trust. He needs to know the costs of various technological systems. He requires some information on the processes he must go through to make good decisions about technologies. He needs to know the implications of using a specific sort of instructional technology not only on the educational system, but on the social, cultural, and political aspects of his country.

This report has a general systems orientation throughout. Today many educators give their support to such an approach to instructional technology. Often, however, those who advocate it are unclear as to what this conceptualization implies and are imprecise in the way they apply it. Before we proceed to the main task of our study, therefore, we shall, in Chapters I and II, outline the relevant concepts of general systems theory and indicate how they can be applied to educational systems.

## INTRODUCTION

### Notes and References

1. Dieuzeide, H. *Educational technology and development of education.* Paris: UNESCO, 1971, 3.
2. Klapper, J. T. *The effects of mass communication.* New York: The Free Press, 1960, 3.

# CHAPTER I

# THE NATURE OF LIVING SYSTEMS*

General systems theory is a set of related definitions, assumptions, and propositions which deal with reality as an integrated hierarchy of organizations of matter and energy. General systems behavior theory is concerned with a special subset of all systems, the living ones.

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* This chapter is a summary of a conceptual statement published as Miller, J. G. Living systems: basic concepts. Behav. Sci., 1965 10, 193-237. See also Living systems: structure and process. Behav. Sci., 1965, 10, 337-379; Living systems: cross-level hypotheses. Behav. Sci., 1965, 10, 380-411; Living systems: the cell. Currents in Mod. Biol., 1971, 4, 78-206; Living systems: the organ. Currents in Mod. Biol., 1971, 4, 207-256; Living systems: the group. Behav. Sci., 1971, 16, 302-398; Living systems: the organization. Behav. Sci., 1972, 17, 1-182.

## 1. Matter and Energy

Matter is anything which has mass (m) and occupies physical space. Energy (E) is defined in physics as the ability to do work. The principle of the conservation of energy states that energy can be neither created nor destroyed in the universe, but it may be converted from one form to another, including the energy equivalent of rest-mass. Matter may have (a) kinetic energy, when it is moving and exerts a force on other matter; (b) potential energy, because of its position in a gravitational field; or (c) rest-mass energy, which is the energy that would be released if mass were converted into the other in accordance with the relation that rest-mass energy is equal to the mass times the square of the velocity of light. Because of the known relationship between matter and energy, throughout the report the joint term matter-energy is used except where one or the other is specifically intended. Living systems require matter-energy, needing specific types of it, in adequate amounts. Heat, light, water, minerals, vitamins, foods, fuels, and raw materials of various kinds, for instance, may be required. Any change of state of matter-energy or its movement over space, from one point to another, is action. It is one form of process.

## 2. Information

Throughout this presentation information (H) will be used in the technical sense first suggested by Hartley in 1928.[1] Later it was developed by Shannon in his mathematical theory of communication.[2] It is not the same thing as meaning or quite the same as information as we usually understand it. Meaning is the significance of information to a system which processes it: it constitutes a change in that system's processes elicited by the information, often resulting from associations made to it on previous experience with it. Information is a simpler concept: the degrees of freedom that exist in a given situation to choose among signals, symbols, messages, or patterns to be transmitted. The total of all these possible categories (the alphabet) is called the ensemble. The amount of information is measured by the binary digit, or bit of information. It is the amount of information which relieves the uncertainty when the outcome of a situation with two equally likely alternatives is known. Legend says the American Revolution was begun by a signal to Paul Revere from Old North Church steeple. It could have been either one or two lights "one if by land or two if by sea." If the alternatives were equally probable, the signal conveyed only one bit of information, resolving the uncertainty in a binary choice. But it carried a vast amount of meaning, meaning which must be measured by other sorts of units than bits.

The term marker refers to those observable bundles, units, or changes of matter-energy whose patterning bears or conveys the informational symbols from the ensemble or repertoire.[3] These might be the stones of Hammurabi's day which bore cuneiform writing, parchments, writing paper, Indians' smoke signals, a door key with notches, punched cards, paper or magnetic tape, a computer's magnetized ferrite core memory, an arrangement of nucleotides in a DNA molecule, the molecular structure of a hormone, pulses on a telegraph wire, or waves emanating from a radio station. The marker may be static, as in a book or in a computer's memory. Communication of any sort, however, requires that the marker move in space, from the transmitting system to the receiving system, and this movement follows the same physical laws as the movement of any other sort of matter-energy. The advance of communication technology over the years has been in the direction of decreasing the matter-energy costs of storing and transmitting the markers which bear information. The efficiency of information processing can be increased by lessening the mass of the markers, making them smaller so they can be stored more compactly and transmitted more rapidly and cheaply. Over the centuries engineering progress has altered the mode in markers from stones bearing cuneiform to magnetic tape bearing electrons, and clearly some limit is being approached.

In recent years systems theorists have been fascinated by the new ways to study and measure information flows, but matter-energy flows are equally important. Systems theory deals both with information theory and with energetics--such matters as the muscular movements of people, the flow of raw materials through societies, or the utilization of energy by brain cells.

It was noted above that the movement of matter-energy over space, action, is one form of process. Another form of process is information processing or communication, which is the change of information from one state to another or its movement from one point to another over space. Communications, while being processed, are often shifted from one matter-energy state to another, from one sort of marker to another. If the form or pattern of the signal remains relatively constant during these changes, the information is not lost. For instance, it is now possible to take a chest X ray, storing the information on photographic film; then a photoscanner can pass over the film line by line, from top to bottom, converting the signals to pulses in an electrical current which represent bits; then those bits can be stored in the core memory of a computer; then those bits can be processed by the computer so that contrasts in the picture pattern can be systematically increased; then the resultant altered patterns can be printed out on a cathode ray tube and photographed. The pattern of the chest structures, the information, modified for easier interpretation, has remained largely invariant throughout all this processing from one sort of marker to another. Similar transformations go on in living systems.

One basic reason why communication is of fundamental importance is that information patterns can be processed over space and the local matter-energy at the receiving point can be organized to conform to, or comply with, this information. As already stated, if the information is conveyed on a relatively small, light, and compact marker, little energy is required for this process. Thus it is a much more efficient way to accomplish the result than to move the entire amount of matter-energy, organized as desired, from the location of the transmitter to that of the receiver. This is the secret of success of the delivery of "flowers by telegraph." It takes much less time and human effort to send a telegram from one city to another requesting a florist in the latter place to deliver flowers locally, than it would to drive or fly with the flowers from the former city to the latter. Also it may turn out to be the secret of successful education at a distance.

Shannon was concerned with mathematical statements describing the transmission of information in the form of signals or messages from a transmitter or a receiver over a channel such as a telephone wire or a radio band.[4] These channels always contain a certain amount of noise. In order to convey a message, signals in channels must be patterned and must stand out recognizably above the background noise.

Matter-energy and information always flow together. Information is always borne on a marker. Conversely there is no regular movement in a system unless there is a difference in potential between two points, which is negative entropy or information. Which aspect of the transmission is most important depends upon how it is handled by the receiver. If the receiver responds primarily to the material or energic aspect, it is a matter-energy transmission; if the response is primarily to the information, it is an information transmission. For example, the banana eaten by a monkey is a nonrandom arrangement of specific molecules, and thus has its informational aspect, but its use to the monkey is chiefly to increase the energy available to him. So it is an energy transmission. The energic character of the signal light that tells him to depress the level which will give him a banana is less important than the fact that the light is part of a nonrandom, patterned organization which conveys information to him. So it is an information transmission. Moreover, just as living systems must have specific forms of matter-energy, so they must have specific patterns of information. For example, some species of animals do not develop normally unless they have appropriate information inputs in infancy. As Harlow showed, for instance, monkeys cannot make proper social adjustments unless they interact with other monkeys during a period between the third and sixth months of their lives.[5]

## 3. System

The term system has a number of meanings. There are systems of numbers and of equations, systems of value and of thought, systems of law, solar systems, organic systems, management systems, command and control systems, electronic systems, even the Amtrak railroad system. The meanings of "system" are often confused. The most general, however, is: A system is a set of interacting units with relationships among them.[6] The word "set" implies that the units have some common properties, which is essential if they are to interact or have relationships. The state of each unit is constrained by, conditioned by, or dependent on the state of other units.[7] The units are coupled.

### 3.1 Conceptual system.

3.1.1 Units. Units of a conceptual system are terms, such as words (commonly nouns, pronouns, and their modifiers), numbers, or other symbols, including those in computer simulations and programs.

3.1.2 Relationships. A relationship of a conceptual system is a set of pairs of units, each pair being ordered in a similar way. *E.g.*, the set of all pairs consisting of a number and its cube is the cubing relationship. Relationships are expressed by words (commonly verbs and their modifiers), or by logical or mathematical symbols, including those in computer simulations and programs, which represent operations, *e.g.*, inclusion, exclusion, identity, implication, equivalence, addition, subtraction, multiplication, or division. The language, symbols, or computer programs are all concepts and always exist in one or more concrete systems, living or nonliving, like a scientist, a textbook, or a computer.

3.2 Concrete system. A concrete system is a nonrandom accumulation of matter-energy, in a region in physical space-time, which is organized into interacting interrelated subsystems or components.

3.2.1 Units. The units (subsystems, components, parts, or members) of these systems are also concrete systems.[8]

3.2.2 Relationships. Relationships in concrete systems are of various sorts, including those that are structural, temporal, spatiotemporal, and meaningful.

Both units and relationships in concrete systems are empirically determinable by some operation carried out by an observer. In theoretical verbal statements about concrete systems, nouns, pronouns, and their modifiers typically refer to concrete systems, subsystems, or components; verbs and their modifiers usually refer to the relationships among them. There are numerous examples, however, in which this usage is reversed and nouns refer to patterns of relationships or processes, such as "nerve impulse," "reflex," "action," "vote," or "annexation."

3.2.3 Open system. Most concrete systems have boundaries which are at least partially permeable, permitting sizeable magnitudes of at least certain sorts of matter-energy or information transmissions to cross them. Such a system is an open system. The functions of such inputs include repairing system components that break down and replacing energy that is used up.

3.2.4 Closed system. A concrete system with impermeable boundaries through which no matter-energy or information transmission of any sort can occur is a closed system. No actual concrete system is completely closed, so concrete systems are either relatively open or relatively closed. Whatever matter-energy happens to be within a relatively closed system is essentially all there is going to be. The energy gradually is used up and the matter gradually becomes disorganized. A body in a hermetically sealed casket, for instance, slowly crumbles and its component molecules become intermingled. Separate layers of liquid or gas in a container move toward random distribution. Gravity may prevent entirely random arrangement.

3.2.5 Nonliving system. Every concrete system which does not have the characteristics of a living system is a nonliving system.

3.2.6 Living systems. The living systems are a special subset of the set of all possible concrete systems, composed of the plants and the animals. They all have the following characteristics:

(a) They are open systems.

(b) They use inputs of foods or fuels to restore their own energy and repair breakdowns in their own organized structure.

(c) They have more than a certain minimum degree of complexity.

(d) They contain genetic material composed of deoxyribonucleic acid (DNA), presumably descended from some primordial DNA common to all life, or have a charter, or both. One or both of these is the template--the original "blueprint" or "program"--of their structure and process from the moment of their origin.

(e) They are largely composed of protoplasm including proteins and other characteristic organic compounds.

(f) They have a decider, the essential critical subsystem which controls the entire system, causing its subsystems and components to interact.

(g) They also have certain other specific critical subsystems or they have symbiotic or parasitic relationships with other living or nonliving systems which carry out the processes of any such subsystem they lack.

(h) Their subsystems are integrated together to form actively self-regulating, developing, reproducing unitary systems, with purposes and goals.

(i) They can exist only in a certain environment. Any change in their environment of such variables as temperature, air pressure, hydration, oxygen content of the atmosphere, or intensity of radiation, outside a relatively narrow range which occurs on the surfact of the earth, produces stresses to which they cannot adjust. Under such stresses they cannot survive.

### 3.3 Abstracted system.

3.3.1 Units. The units of abstracted systems are relationships abstracted or selected by an observer in the light of his interests, theoretical viewpoint, or philosophical bias. Some relationships may be empirically determinable by some operation carried out by the observer, but others are not, being only his concepts.

3.3.2 Relationships. The relationships mentioned above are observed to inhere and interact in concrete, usually living, systems. In a sense, then, these concrete systems are the relationships of abstracted systems. The verbal usages of theoretical statements concerning abstracted systems are often the reverse of those concerning concrete systems: the nouns and their modifiers typically refer to relationships and the verbs and their modifiers (including predicates) to the concrete systems in which these relationships inhere and interact. These concrete systems are empirically determinable by some operation carried out by the observer. A theoretical statement oriented to concrete systems typically would say "Lincoln was President," but one oriented to abstracted systems, concentrating on relationships or roles, would very likely be phrased "The Presidency was occupied by Lincoln."[9]

An abstracted system differs from an abstraction, which is a concept (like those that make up conceptual systems) representing a class of phenomena all of which are considered to have some similar "class characteristic." The members of such a class are not thought to interact or be interrelated, as are the relationships in an abstracted system.

Abstracted systems are much more common in social science theory than in natural science.

Parsons has attempted to develop general behavior theory using abstracted systems.[10] To some a social system is something concrete in space-time, observable and presumably measurable by techniques like those of natural science. To Parsons the system is abstracted from this, being the set of relationships which are the form of organization. To him the important units are classes of input-output relationships of subsystems rather than the subsystems themselves.

3.4 Abstracted vs. concrete systems. One fundamental distinction between abstracted and concrete systems is that the boundaries of abstracted systems may at times be conceptually established at regions which cut through the units and relationships in the physical space occupied by concrete systems, but the boundaries of these latter systems are always set at regions which include within them all the units and internal relationships of each system.

A science of abstracted systems certainly is possible and under some conditions may be useful. When Euclid was developing geometry, with its practical applications to the arrangement of Egyptian real estate, it is possible that the solid lines in his figures were originally conceived to represent the borders of land areas or objects. Sometimes, as in Figure 1, he would use dotted "construction lines" to help conceptualize a geometric proof. The dotted line did not correspond to any actual border in space, Triangle ABD would be shown to be congruent to Triangle CBD, and therefore the angle BAD was equal to the angle BCD. After the proof was completed, the dotted line might well be erased, since it did not correspond to anything real and was useful only for the proof. Such construction lines, representing relationships among real lines, were used in the creation of early forms of abstracted systems.

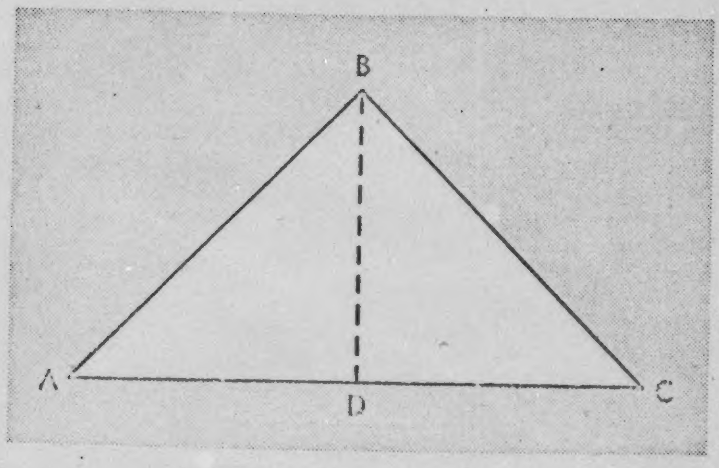

Figure 1. A Euclidean Figure

If the diverse fields of science are to be unified, it would help if all disciplines were oriented either to concrete or to abstracted systems. It is of paramount importance for scientists to distinguish clearly between them. To use both kinds of systems in theory leads to unneccesary problems. It would be best if one type of system or the other were generally used in all disciplines.

All three meanings of "system" are useful in science, but confusion results when they are not differentiated. A scientific endeavor may appropriately begin with a conceptual system and evaluate it by collecting data on a concrete or on an abstracted system or it may equally well first collect the data and then determine what conceptual system it fits. Throughout this report the single word "system," for brevity, will always mean "concrete system." The other sorts of systems will always be explicitly distinguished as either "conceptual system" or "abstracted system."

## 4. Structure

The structure of a system is the arrangement of its subsystems and components in three-dimensional space at a given moment of time. This always changes over time.[11] It may remain relatively fixed for a long period or it may change from moment to moment, depending upon the characteristics of the process in the system. This process halted at any given moment, as when motion is frozen by a high-speed photograph, reveals the three-dimensional spatial arrangement of the system's components as of that instant.

## 5. Process

All change over time of matter-energy or information in a system is process. If the equation describing a process is the same no matter whether the temporal variable is positive or negative, it is a reversible process; otherwise it is irreversible. Process includes the on-going function of a system, reversible actions succeeding each other from moment to moment. Process also includes history, less readily reversed changes like mutations, birth, growth, development, aging, and death; changes which commonly follow trauma or disease; and the changes resulting from learning which are not later forgotten. Historical processes alter both the structure and the function of the system. The statement "less readily reversed" has been used instead of "irreversible" (although many such changes are in fact irreversible) because structural changes sometimes can be reversed. *E.g.*, a component which has developed and functioned may atrophy and finally disappear with disuse; a functioning part may be cut off and regrow. History, then, is more than the passage of time. It involves also accumulation in the system of residues or effects of past events (structural changes, memories, and learned habits). A living system carries its history with it in the form of altered structure, and consequently of altered function also. So there is a circular relation among the three primary aspects of systems--structure changes momentarily with functioning, but when such change is so great that it is essentially irreversible, a historical process has occurred, giving rise to a new structure.

## 6. Type

If a number of individual living systems are observed to have similar characteristics, they often are classed together as a type. Types are abstractions. Nature presents an apparently endless variety of living things which man, from his earliest days, has observed and classified--first, probably, on the basis of their threat to him, their susceptibility to capture, or their edibility, but eventually according to categories which are scientifically more useful. Classification by species is applied to organisms, plants or animals, or to free-living cells, because of their obvious relationships by reproduction. These systems are classified together by taxonomists on the basis of likeness of structure and process, genetic similarity and ability to interbreed, and local interaction, often including, in animals, ability to respond appropriately to each other's signs.

There are various types of systems at other levels of the hierarchy of living systems besides the cell and organism levels, each classed according to different structural and process taxonomic differentia. There are, for instance, the less developed primitive or agricultural societies, and there are industrial societies.

## 7. Level

The universe contains a hierarchy of systems, each higher level of system being composed of systems of lower levels.[12] Atoms are composed of particles; molecules, of atoms; crystals and organelles, of molecules.

About at the level of crystalizing viruses, like the tobacco mosaic virus, the subset of living systems begins. Viruses are necessarily parasitic on cells, so cells are the lowest level of living systems. Cells are composed of atoms, molecules, and multimolecular organelles; organs are composed of cells aggregated into tissues; organisms, of organs; groups (e.g., herds, flocks, families, teams, tribes), of organisms; organizations, of groups (and sometimes single individual organisms); societies, of organizations, groups, and individual organisms or persons; and supranational systems, of societies and organizations. Higher levels of systems may be of mixed composition, living and nonliving. They include planets, solar systems, galaxies, and so forth. It is beyond the scope of our concern in this report to deal with all the levels of systems. We shall be concerned only with five levels of living systems: organisms, groups, organizations, societies, and supranational systems.

What are the criteria for distinguishing any one level from the others? They are derived from a long scientific tradition of empirical observation of the entire gamut of living systems. This extensive experience of the community of scientific observers has led to a consensus that there are certain fundamental forms of organization of living matter-energy. Indeed the classical division of subject-matter among the various disciplines of the life or behavioral sciences is implicitly or explicitly based upon this consensus.

It is important to follow one procedural rule in systems theory, in order to avoid confusion. Every discussion should begin with an identification of the level of reference, and the discourse should not change to another level without a specific statement that this is occurring.[13] Systems at the indicated level are called systems. Those at the level above are *suprasystems*, and at the next higher level, *suprasuprasystems*. Below the level of reference are *subsystems*, and below them *subsubsystems*. For example, if one is studying a group, its member organisms make up its subsystems, and an organization of which the group is a part is its suprasystem.[14]

*7.1 Intersystem generalization*. A fundamental procedure in science is to make generalizations from one system to another on the basis of some similarity between the systems, which the observer sees and which permits him to class them together. For example, since the Nineteenth Century, the field of "individual differences" has been expanded, following the tradition of scientists like Galton in anthropometry and Binet in psychometrics. In Figure 2, states of separate specific individual systems on a specific structural or process variable are represented by $I_1$ to $I_n$. For differences among such individuals to be observed and measured, of course, a variable common to the type, along which there are individual

$$\underbrace{I_1 . \; . \; . \; . I_n}_{\underbrace{T_1 . \; . \; . \; . T_n}_{L_1 . \; . \; . \; . L_n}}$$

*Figure 2*. *Individual, Type, Level*.

variations, must be recognized ($T_1$). Physiology depends heavily, for instance, upon the fact that individuals of the type (or species) of living organisms called cats are fundamentally alike, even though minor variations from one individual to the next are well recognized.

Scientists may also generalize from one type to another ($T_1$ to $T_n$). An example is cross-species generalization, which has been commonly accepted only since Darwin. It is the justification for the labors of the white rat in the cause of man's understanding of himself. Rats and cats, cats and chimpanzees, chimpanzees and human beings are similar in structure, as comparative anatomists know, and in function, as comparative physiologists and psychologists demonstrate.

The amount of variance among species is greater than among individuals within a species If the learning behavior of cat Felix is compared with that of mouse Mickey, we would expect not only the sort of individual differences which are found between Mickey and Minnie Mouse, but also greater species differences. Cross-species generalizations are common, and many have good scientific acceptability, but in making them, inter-individual and interspecies differences must be kept in mind. The learning rate of men is not identical to that of white rats, and no single man learns at exactly the same rate as any other.

The third type of scientific generalization indicated in Figure 2 is from one level to another. The basis for such generalization is the assumption that each of the levels of life, from cell to society, is composed of systems of the previous lower level. These cross-level generalizations will, ordinarily, have greater variance than the other sorts of generalizations, since they include variance among types and among individuals. But they can be made, and they can have great conceptual significance.

That there are important uniformities, which can be generalized about, across all levels of living systems is not surprising. All are composed of comparable carbon-hydrogen-nitrogen constituents, most importantly a score of amino acids organized into similar proteins, which are produced in nature only in living systems. All are equipped to live in a water-oxygen world rather than, for example, on the methane and ammonia planets so dear to science fiction. Also they are all adapted only to environments in which the physical variables, like temperature, hydration, pressure, and radiation, remain within relatively narrow ranges.[15] Moreover, they all presumably have arisen from the same primordial genes or template, diversified by evolutionary change. Perhaps the most convincing argument for the plausibility of cross-level generalization derives from analysis of this evolutionary development of living systems. Although increasingly complex types of living systems have evolved at a given level, followed by higher levels with even greater complexity, certain basic necessities did not change. All these systems, if they were to survive in their environment, had, by some means or other, to carry out the same vital subsystem processes. While free-living cells, like protozoans, carry these out with relative simplicity, the corresponding processes are more complex in multicellular organisms like mammals, and even more complex in organizations, societies, and supranational systems. The same processes are "shredded out" to multiple components in a more complex system, by the sort of division of labor which Parkinson has made famous as a law.[16] This results in formal identities across levels of systems, more complex subsystems at higher levels carrying out the same fundamental processes as simpler subsystems at lower levels.

A formal identity among concrete systems is demonstrated by a procedure composed of three logically independent steps: (a) recognizing an aspect of two or more systems which has comparable status in those systems; (b) hypothesizing a quantitative identity between them; and (c) demonstrating that identity within a certain range of error by collecting data on a similar aspect of each of the two or more systems being compared. It may be possible to formulate some useful generalizations which apply to all living systems at all levels. A comparision of systems is complete only when statements of their formal identities are associated with specific statements of their interlevel, intertype, and interindividual disidentities. The confirmation of formal identities and disidentities is done by research.

What makes interindividual, intertype, or interlevel formal identities among systems important and of absorbing interest, is that--if they can be conclusively demonstrated--very different structures, which carry out similar processes, may well turn out to carry out acts so much alike that they can be quite precisely described by the same formal model. Conversely, it may perhaps be shown as a general principle that subsystems with comparable structures but quite different processes may have quantitative similarities as well.

7.2 Emergents. The more complex systems at higher levels manifest characteristics, more than the sum of the characteristics of the units, not observed at lower levels. These characteristics have been called emergents. Significant aspects of living systems at higher levels will be neglected if they are described only in terms and dimensions used for their lower-level subsystems and components.

A clear-cut illustration of emergents can be found in a comparison of three electronic systems. One of these--wire connecting the poles of a battery--can only conduct electricity, which heats the wire. Add several tubes, condensers, resistors, and controls, and the new system can become a radio, capable of receiving sound messages. Add dozens of other components, including a picture tube and several more controls, and the system becomes a television set which can receive sound and a picture. And this is not just more of the same. The third system has emergent capabilities the first system did not have, emergent from its special design of much greater complexity, just as the second has capabilities the first lacked. But there is nothing mystical about the colored merry-go-round and racing children on the TV screen--it is the output of a system which can be completely explained by a complicated set of differential equations such as electrical engineers write, including terms representing the characteristics of each of the set's components.

## 8. Echelon

This concept may seem superficially similar to the concept of level, but is distinctly different. Many complex living systems, at various levels, are organized into two or more echelons (in the military sense of a step in the "chain of command," not in the other military sense of arrangement of troops in rows in physical space). In living systems with echelons the components of the decider, the decision-making subsystem, are hierarchically arranged so that usually certain types of decisions are made by one component of that subsystem and others by another. Each is an echelon. All echelons are within the boundary of the decider subsystem. Ordinarily each echelon is made up of components of the same level as those which make up every other echelon in that system. Characteristically the decider component at one echelon gets information from a source or sources which process information primarily or exclusively to and from that echelon.

After a decision is made at one echelon on the basis of the information received, it is transmitted, often through a single subcomponent which may or may not be the same as the decider, but possibly through more than one subcomponent, upward to the next higher echelon, which goes through a similar process, and so on to the top echelon. Here a final decision is made and then command information is transmitted downward to lower echelons. Characteristically information is abstracted or made more general as it proceeds upward from echelon to echelon and it is made more specific or detailed as it proceeds downward. If a given component does not decide but only passes on information, it is not functioning as an echelon. In some cases of decentralized decision making, certain types of decisions are made at lower echelons and not transmitted to higher echelons in any form, while information relevant to other types of decisions is transmitted upward. If there are multiple parallel deciders, without a hierarchy that has subordinate and superordinate deciders, there is not one system but multiple ones.

## 9. Suprasystem

9.1 Suprasystem and environment. The suprasystem of any living system is the next higher system in which it is a component or subsystem. For example, the suprasystem of a cell or tissue is the organ it is in; the suprasystem of an organism is the group it is in at the time. Presumably every system has a suprasystem except the "universe." The suprasystem is differentiated from the environment. The immediate environment is the suprasystem minus the system itself. The entire environment includes this plus the suprasuprasystem and the systems at all higher levels which contain it. In order to survive the system must interact with and adjust to its environment, the other parts of the suprasystem. These processes alter both the system and its environment. Living systems adapt to their environment, and in return mold it. The result is that, after some period of interaction, each in some sense becomes a mirror of the other.

9.2 Territory. The region of physical space occupied by a living system, and frequently protected by it from an invader, is its territory.[17] Examples are a bowerbird's stage, a dog's yard, a family's property, a nation's land.

## 10. Subsystem and Component

In every system it is possible to identify one sort of unit, each of which carries out a distinct and separate process, and another sort of unit, each of which is a discrete, separate structure. The totality of all the structures in a system which carry out a particular process is a subsystem. A subsystem, thus, is identified by the process it carries out. It exists in one or more identifiable structural units of the system. These specific, local, distinguishable structural units are called components or members or parts. Reference has been made to these components in the definition of a concrete system as "a nonrandom accumulation of matter-energy, in a region in physical space-time, which is organized into interacting, interrelated subsystems or components." There is no one-to-one relationship between process and structure. One or more processes may be carried out by two or more components. Every system is a component, but not necessarily a subsystem of its suprasystem. Every component that has its own decider is a system at the next lower level, but many subsystems are not systems at the next lower level, being dispersed to several components.

The concept of subsystem process is related to the concept of role used in social science.[18] Organization theory usually emphasizes the functional requirements of the system which the subsystem fulfills, rather than the specific characteristics of the component or components that make up the subsystem. The typical view is that an organization specifies clearly defined roles (or component processes) and human beings "fill them."[19] But it is a mistake not to recognize that characteristics of the component--in this case the person carrying out the role--also influence what occurs. A role is more than simple "social position." It involves interaction, adjustments between the component and the system. It is a multiple concept, referring to the demands upon the component by the system, to the internal adjustment processes of the component, and to how the component functions in meeting the system's requirements. The adjustments it makes are frequently compromises between the requirements of the component and the requirements of the system.

The way living systems develop does not always result in a neat distribution of exactly one subsystem to each component. The natural arrangement would appear to be for a system to depend on one structure for one process. But there is not always such a one-to-one relationship. Sometimes the boundaries of a subsystem and a component exactly overlap, are congruent. Sometimes they are not congruent. There can be (*a*) a single subsystem in a single component; (*b*) multiple subsystems in a single component; (*c*) a single subsystem in multiple components; or (*d*) multiple subsystems in multiple components.

Systems differ markedly from level to level, type to type, and even from individual to individual, in their *patterns of allocation* of various subsystem processes to different structures. Such process may be (*a*) localized in a single component; (*b*) combined with others in a single component; (*c*) dispersed laterally to other components in the system; (*d*) dispersed upwardly to the suprasystem or above; (*e*) dispersed downwardly to subsubsystems or below; or (*f*) dispersed outwardly to other systems external to the hierarchy it is in. Which allocation pattern is employed is a fundamental aspect of any given system. For a specific subsystem function in a specific system one strategy results in more efficient process than another. One can be better than another in maximizing effectiveness and minimizing costs. Valuable studies can be made at each level on optimal patterns of allocation of processes to structures. In all probability there are general systems principles which are relevant to such matters. Possible examples are: (a) Structures which minimize the distance over which matter-energy must be transported or information transmitted are the most efficient. (b) If multiple components carry out a process, the process is more difficult to control and less efficient than if a single component does it. (c) If one or more components which carry out a process are outside the system, the process is more difficult to integrate than if they are all in the system. (d) Or if there are duplicate components capable of performing the same process, the system is less vulnerable to stress and therefore is more likely to survive longer, because if one component is inactivated, the other can carry out the process alone.

10.1 Critical subsystem. Certain processes are necessary for life and must be carried out by all living systems that survive or be performed for them by some other system. They are carried out by the following critical subsystems listed in Table 1.

The definitions of the critical subsystems are as follows:

10.1.1 Subsystems which process both matter-energy and information.

Reproducer, the subsystem which is capable of giving rise to other systems similar to the one it is in.

Boundary, the subsystem at the perimeter of a system that holds together the components which make up the system, protects them from environmental stresses, and excludes or permits entry to various sorts of matter-energy and information.

10.1.2 Matter-energy processing subsystems.

Ingestor, the subsystem which brings matter-energy across the system boundary from the environment.

| Matter-Energy Processing Subsystems | Subsystems Which Process Both Matter-Energy and Information | Information Processing Subsystems |
|---|---|---|
| | Reproducer | |
| | Boundary | |
| Ingestor | | Input Transducer |
| | | Internal Transducer |
| Distributor | | Channel and Net |
| Converter | | Decoder |
| Producer | | Associator |
| Matter-Energy Storage | | Memory |
| | | Decider |
| | | Encoder |
| Extruder<br>Motor | | Output Transducer |
| Supporter | | |

Table 1. The Critical Subsystems.

Distributor, the subsystem which carries inputs from outside the system or outputs from its subsystems around the system to each component.

Converter, the subsystem which changes certain inputs to the system into forms more useful for the special processes of that particular system.

Producer, the subsystem which forms stable associations that endure for significant periods among matter-energy inputs to the system or outputs from its converter, the materials synthesized being for growth, damage repair, or replacement of components of the system, or for providing energy for moving or constituting the system's outputs of products or information markers to its suprasystem.

Matter-energy storage, the subsystem which retains in the system, for different periods of time, deposits of various sorts of matter-energy.

Extruder, the subsystem which transmits matter-energy out of the system in the forms of products and wastes.

Motor, the subsystem which moves the system or parts of it in relation to part or all of its environment or moves components of its environment in relation to each other.

Supporter, the subsystem which maintains the proper spatial relationships among components of the system, so that they can interact without weighting each other down or crowding each other.

### 10.1.3 Information processing subsystems.

Input transducer, the sensory subsystem which brings markers bearing information into the system, changing them to other matter-energy forms suitable for transmission within it.

Internal transducer, the sensory subsystem which receives, from all subsystems or components within the system, markers bearing information about significant alterations in those subsystems or components, changing them to other matter-energy forms of a sort which can be transmitted within it.

Channel and net, the subsystem composed of a single route in physical space, or multiple interconnected routes, by which markers bearing information are transmitted to all parts of the system.

Decoder, the subsystem which alters the code of information input to it through the input transducer or the internal transducer into a "private" code that can be used internally by the system.

Associator, the subsystem which carries out the first stage of the learning process, forming enduring associations among items of information in the system. (The main topic of this report is the associator subsystem or educational sector of a society.)

Memory, the subsystem which carries out the second stage of the learning process, storing various sorts of information in the system for different periods of time.

Decider, the executive subsystem which receives information inputs from all other subsystems and transmits to them information outputs that control the entire system.

Encoder, the subsystem which alters the code of information inputs to it from other information processing subsystems, from a "private" code used internally by the system into a "public" code which can be interpreted by other systems in its environment.

Output transducer, the subsystem which puts out markers bearing information from the system, changing markers within the system into other matter-energy forms which can be transmitted over channels in the system's environment.

Of these critical subsystems only the decider is essential, in the sense that a system cannot be dependent on another system for its deciding. There is no living system if the decider is dispersed upwardly, downwardly, or outwardly.

Since all living systems are genetically related, have similar constituents, live in closely comparable environments, and process matter-energy and information, it is not surprising that they should have comparable subsystems and relationships among them. All systems do not have all possible kinds of subsystems. They differ individually, among types, and across levels, as to which subsystems they have and the structures of those subsystems. But all living systems either have a complete complement of the above listed critical subsystems carrying out the functions essential to life or are intimately associated with and effectively interacting with systems which carry out the missing life functions for them.

10.2 Inclusion. Sometimes a part of the environment is surrounded by a system and totally included within its boundary. Any such thing not a part of the system's own living structure is an inclusion. Any living system at any level may include living or nonliving components. To the two-member group of one dog and one cat, for instance, an important plant component is often added--one tree. An airline firm may have as an integral component a computerized mechanical system for making reservations which extends into all its offices. A nation includes many sorts of vegetables, minerals, buildings, and machines, as well as its land.

The inclusion is a component or subsystem of the system if it carries out or helps in carrying out a critical process of the system; otherwise it is part of the environment. Either way the system, to survive, must adjust to its characteristics. If it is harmless or inert it can often be left undisturbed. But if it is potentially harmful--like a pathogenic bacterium in a dog or a Greek in the giant gift horse within the gates of Troy--it must be rendered harmless or walled off or extruded from the system or killed. Because it moves with the system in a way the rest of the environment does not, it constitutes a special problem. Being inside the system it may be a more serious or more immediate stress than it would be outside the system's protective boundary. But also, the system that surrounds it can control its physical actions and all routes of access to it. For this reason international law has developed the concept of extraterritoriality to provide freedom of action to ambassadors and embassies, nations' inclusions within foreign countries.

10.3 Artifact. An artifact is an inclusion in some system, made by animals or man. Spider webs, bird nests, beaver dams, houses, books, machines, music, paintings, and language are artifacts. They may or may not be prostheses, inventions which carry out some critical process essential to a living system. An artificial pacemaker for a human heart is an example of an artifact which can replace a pathological process with a healthy one. Instructional technologies are artifacts which function as prostheses in educational systems at the level of the individual student or organism and at higher levels. Chemical, mechanical, or electronic artifacts have been constructed which carry out some functions at all levels of living systems.

Living systems create and live among their artifacts. Beginning presumably with the hut and the arrowhead, the pot and the vase, the plow and the wheel, mankind has constructed tools and devised machines. The Industrial Revolution of the Nineteenth Century, capped by the recent harnessing of atomic energy, represents the extension of man's matter-energy processing ability, his muscles. A new Industrial Revolution, of even greater potential, is just beginning in the Twentieth Century, with the development of information and logic-processing machines, adjuncts to man's brain. These artifacts are increasingly becoming prostheses, relied on to carry out critical subsystem processes. A chimpanzee may extend his reach with a stick; a man may extend his cognitive skills with a computer. Today's prostheses include input transducers which sense the type of blood cells that pass before them and identify missiles that approach a nation's shores; photographic, mechanical, and electronic memories which can store masses of information over time; computers which can solve problems, carry out logical and mathematical calculations, make decisions, and control other machines; electric typewriters, high speed printers, cathode ray tubes, and photographic equipment which can output information. An analysis of many modern systems must take into account the novel problems which arise at man-machine interfaces.

Music is a special sort of human artifact, an information-processing artifact.[20] So are the other arts and cognitive systems which people share. So is language. Whether it be a natural language or the machine language of some computer system, it is essential to information processing. Often stored only in human brains and expressed only by human lips, it can also be recorded on nonliving artifacts like stones, books, and magnetic tapes. It is not of itself a concrete system. It changes only when man changes it. As long as it is used it is in flux, because it must remain compatible with the ever-changing living systems that use it. But the change emanates from the users, and without their impact the language is inert. The artifactual language used in any information transmission in a system determines many essential aspects of that system's structure and process.[21]

## 11. Transmissions in Concrete Systems

All process involves some sort of transmission among subsystems within a system, or among systems. There are inputs across the boundary into a system, internal processes within it, and outputs from it. Each of these sorts of transmissions may consist of either (a) some particular form of matter; (b) energy, in the form of light, radiant energy, heat, or chemical energy; or (c) some particular pattern of information.

## 12. Steady State

When opposing variables in a system are in balance, that system is in equilibrium with regard to them. The equilibrium may be static and unchanging or it may be maintained in the midst of dynamic change. Since living systems are open systems, with continually altering fluxes of matter-energy and information, many of their equilibria are dynamic and are often referred to as flux equilibria of steady states. These may be unstable, in which a slight disturbance elicits progressive change from the equilibrium state--like a ball standing on an inverted bowl; or stable, in which a slight disturbance is counteracted so as to restore the previous state--like a ball in a cup; or neutral, in which a slight disturbance makes a change, but without cumulative effects of any sort--like a ball on a flat surface with friction.

All living systems tend to maintain steady states (or homeostasis) of many variables, keeping an orderly balance among subsystems which process matter-energy or information. Not only are subsystems usually kept in equilibrium, but systems also ordinarily maintain steady states with their environments and suprasystems, which have outputs to the systems and inputs from them. This prevents variations in the environment from destroying systems. The variables of living systems are constantly fluctuating, however. A moderate change in one variable may produce greater or lesser alterations in other related ones. These alterations may or may not be reversible.

*12.1 Stress, strain, and threat*. There is a *range of stability* for each of numerous variables in all living systems. It is that range within which the rate of correction of deviations is minimal or zero, and beyond which correction occurs. An input or output of either matter-energy or information, which by lack or excess of some characteristic, forces the variables beyond the range of stability, constitutes a *stress* and produces a *strain* (or strains) within the system. Input lack and output excess both produce the same strain--diminished amounts in the system. Input excess and output lack both produce the opposite strain--increased amounts. Strains may or may not be capable of being reduced, depending upon their intensity and the resources of the system. The totality of the strains within a system resulting from its template program and from variations in the inputs from its environment can be referred to as its *values*. The relative urgency of reducing each of these specific strains represents its *hierarchy of values*.

Stress may be anticipated. Information that a stress is imminent constitutes a *threat* to the system. A threat can create a strain. Recognition of the meaning of the information of such a threat must be based on previously stored (usually learned) information about such situations. A pattern of input information is a threat when--like the odor of the hunter on the wind or a whirling cloud approaching the city--it is capable of eliciting processes which can counteract the stress it presages. Processes--actions or communications--occur in systems only when a stress or a threat has created a strain which pushes a variable beyond its range of stability. A system is a constantly changing cameo and its environment is a similarly changing intaglio, and the two at all times fit each other. That is, outside stresses or threats are mirrored by inside strains. Matter-energy storage and memory also mirror the past environment, but with certain alterations.

12.1.1 Matter-energy stress. There are various ways for systems to be stressed. One class of stresses is the matter-energy stresses, including: (a) matter-energy input lack or underload--starvation or inadequate fuel input; (b) input of an excess or overload of matter-energy; and (c) restraint of the system, binding it physically. [This may be the equivalent of (a) or (b).]

12.1.2 Information stress. Also there are information stresses, including: (a) information input lack or underload, resulting from a dearth of information in the environment or from improper function of the external sense organs or input transducers; (b) injection of noise into the system, which has an effect of information cut-off, much like the previous stress; and (c) information input excess or overload. Informational stresses may involve changes in the rate of information input or in its meaning.

12.2 Adjustment processes. Those processes of subsystems which maintain steady states in systems, keeping variables within their ranges of stability despite stresses, are adjustment processes. In some systems a single variable may be influenced by multiple adjustment processes. As Ashby has pointed out, a living system's adjustment processes are so coupled that the system is ultrastable.[22] This characteristic can be illustrated by the example of an army cot. It is made of wires, each of which would break under a 300-pound weight, yet it can easily support a sleeper of that weight. The weight is applied to certain wires, and as it becomes greater, first nearby links and then those farther and farther away, take up part of the load. Thus a heavy weight which would break any of the component wires alone can be sustained. In a living system, if one component cannot handle a stress, more and more others are recruited to help. Eventually the entire capacity of the system may be involved in coping with the situation.

12.2.1 Feedback. The term feedback means that there exist two channels, carrying information, such that Channel B loops back from the output to the input of Channel A and transmits some portion of the signals emitted by Channel A (see Figure 3).[23] These are tell-tales or monitors of the outputs of Channel A. The transmitter on Channel A is a device with two inputs, formally represented by a function with two independent variables, one the signal to be transmitted on Channel A and the other a previously transmitted signal fed back on Channel B. The new signal transmitted on Channel A is selected to decrease the strain resulting from any

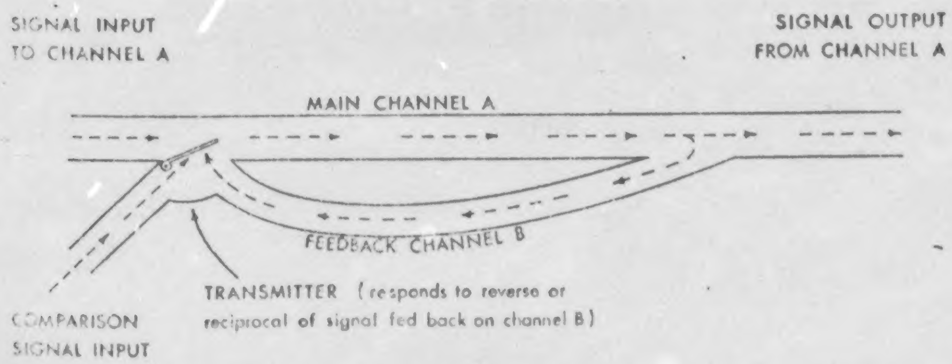
SIGNAL INPUT
TO CHANNEL A
SIGNAL OUTPUT
FROM CHANNEL A
MAIN CHANNEL A
FEEDBACK CHANNEL B
TRANSMITTER (responds to reverse or
reciprocal of signal fed back on channel B)
COMPARISON
SIGNAL INPUT

Figure 3. Negative Feedback

error or deviation in the feedback signal from a criterion or comparison reference signal indicating the state of the output of Channel A which the system seeks to maintain steady. This provides control of the output of Channel A on the basis of actual rather than expected performance.

When the signals are fed back over the feedback channel in such a manner that they increase the deviation of the output from a steady state, positive feedback exists. When the signals are reversed, so that they decrease the deviation of the output from a steady state, it is negative feedback. Positive feedback alters variables and destroys their steady states. Thus it can initate system changes. Unless limited, it can alter variables enough to destroy systems. At every level of living systems numerous variables are kept in a steady state, within a range of stability, by negative feedback controls. When these fail, the structure and process of the system alter markedly--perhaps to the extent that the system does not survive. Feedback control always exhibits some oscillation and always has some lag. When the organism maintains its balance in space, this lag is caused by the slowness of transmissions in the nervous system, but is only of the order of hundredths of seconds. An organization, like a corporation, may take hours to correct a breakdown in an assembly line, days or weeks to correct a bad management decision. In a society the lag can sometimes be so great that, in effect, it comes too late. General staffs often plan for the last war rather than the next. Governments receive rather slow official feedbacks from the society at periodic elections. They can, however, get faster feedbacks from the press, other mass media, picketers, or demonstrators. Public opinion surveys can accelerate the social feedback process. The speed and accuracy of feedback have much to do with the effectiveness of the adjustment processes they mobilize.

12.2.2 Power. In relation to energy processing, power is the rate at which work is performed, work being calculated as the product of a force and the distance through which it acts. The term also has another quite different meaning. In relation to information processing, power is control, the ability of one system to elicit compliance from another, at the same or a different level. A system transmits a command signal or message to a given address with a signature identifying the transmitter as a legitimate source of command information. The message is often in the imperative mode, specifying an action the receiver is expected to carry out. It elicits compliance at the lower levels because the electrical or chemical form of the signal sets off a specific reaction. At higher levels the receiving system is likely to comply because it has learned that the transmitter is capable of evoking rewards or punishments from the suprasystem, depending on how the receiver responds.

12.2.3 Purpose and goal. By the information input of its charter or genetic input, or by changes in behavior brought about by rewards and punishments from its suprasystem, a system develops a preferential hierarchy of values that gives rise to decision rules which determine its preference for one internal steady state value rather than another. This is its purpose. It is the comparison value which it matches to information received by negative feedback in order to determine whether the variable is being maintained at the appropriate steady state value. In this sense it is normative. The system then takes one alternative action rather than another because it appears most likely to maintain the steady state. When disturbed, this state is restored by the system by successive approximations, in order to relieve the strain of the disparity recognized internally between the feedback signal and the comparison signal. Any system may have multiple purposes simultaneously.

A system may also have an external goal, such as reaching a target in space, or developing a relationship with any other system in the environment. Or it may have several goals at the same time. Just as there is no question that a guided missile is zeroing in on a target, so there is no question that a rat in a maze is searching for the goal of food at its end or that the Greek people under Alexander the Great were seeking the goal of world conquest. As Ashby notes, natural selection permits only those systems to continue which have goals that enable them to survive in their particular environments.[24] The external goal may change constantly, as when a hunter chases a moving fox or a man searches for a wife by dating one girl after another, while the internal purpose remains the same.

A system's hierarchy of values determines its purposes as well as its goals. It is not difficult to distinguish purposes from goals, as the terms have been used: a boy has the purpose of keeping his body temperature in the proper range and so he has the goal of finding and putting on his sweater; Poland had the purpose in March 1939 of remaining uninvaded and autonomous and so she sought the goal of a political alliance with Britain and France in order to have assistance in keeping both Germany and Russia from crossing her borders.

12.2.4 Costs and efficiency. All adjustment processes have their costs, in energy of nonliving or living systems, in material resources, in information (including in social systems a special form of information, money, often conveyed on a metal or paper marker), or in time required for an action. Any of these may be scarce. (Time is a scarcity for mortal living systems.) Any of these is valued if it is essential for reducing strains. The costs of adjustment processes differ from one to another and from time to time. They may be immediate or delayed, short-term or long-term.

How successfully systems acomplish their purposes can be determined if those purposes are known. A system's efficiency, then, can be determined as the ratio of the success of its performance to the costs involved. A system constantly makes economic decisions directed toward increasing its efficiency by decreasing costs and improving performance or effectiveness. Economic analyses of cost-effectiveness are in recent years frequently aided by program budgeting. This involves keeping accounts separately for each subsystem or component that carries out a distinct program. The matter-energy, information, money, and time costs of the program are in such analyses compared with various measures of the effectiveness or performance of the program. How efficiently a system adjusts to its environment is determined by what strategies it employs in selecting adjustment processes and whether they satisfactorily reduce strains without being too costly. This decision process can be analyzed by game theory, a mathematical approach to economic decisions. This is a general theory concerning the best strategies for weighing "plays" against "pay-offs," for selecting actions which will increase profits while decreasing losses, increase rewards while decreasing punishments, improve adjustments of variables to appropriate steady state values, or attain goals while diminishing costs. Relevant information available to the decider can improve such decisions. Consequently such information is valuable. But there are costs to obtaining such information.

## 13. Conclusion

This analysis of living systems uses concepts of thermodynamics, information theory, cybernetics, and systems engineering, as well as the classical concepts appropriate to each level. The purpose is to produce a description of living structure and process in terms of input and output, flows through systems, steady states, and feedbacks, which will clarify and unify the facts of life. In the subsequent chapters these systems concepts will be applied to a particular class of living systems--educational systems. Emphasis will be placed on the potential of a particular class of artifacts--the new information processing technologies--for improving the quality and efficiency of educational programs and cutting their costs.

## CHAPTER I

## Notes and References

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12. Note: This concept is not a product of our times. It was developed long ago. For instance, in the middle of the Nineteenth Century, Virchow (Virchow, R. Atome und Individuen, Vier Reden Uber Leben und Krankstein. Berlin, 1862. Trans. by L. J. Rather as: Atoms and individuals. In Disease, life, and man, selected essays by Rudolph Virchow. Stanford, Calif.: Stanford Univ. Press, 1958, 120-141.) wrote that the scope of the life sciences must include the cellular, tissue, organism, and social levels of living organization. In modern times the concept of hierarchical levels of systems is basic t to the thought of Bertalanffy and other general systems theorists. (Bertalanffy, L. v. Op. cit., 7.)

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# CHAPTER II

# THE LIVING SYSTEMS INVOLVED IN THE EDUCATIONAL PROCESS

## 1. The Levels of Educational Systems

How can the concepts of general systems theory be applied to increase our understanding of the educational process in less developed nations and our ability to improve it? A number of levels of living systems are involved in this process, carried out by the associator subsystem, i.e., the educational sector (see pages 37 and 39 ) of the particular society in a given country.

At the organism level, there are several sorts of persons: the student, the parent, the teacher, the paraprofessional teacher, the administrator, and other employees of educational institutions. At the group level: the class in the classroom, the teacher and student in a tutorial session, or the studio team in an educational television station. At the organization level: in primary and secondary education, the school, and in higher education, the college or university; also at a higher echelon, the school system or the statewide educational agency which coordinates formal education and at times a part of the more inclusive nonformal education. At the society level: the national educational system, which exercises little centralized control in the United States but is much more centralized in the Soviet Union, Brazil, and elsewhere. Finally, at the supranational level: UNESCO, the Economic and Social Council of the United Nations, INNOTECH of the eight Southeast Asian nations, the Pan American Federation of Associations of Schools of Medicine, and other such activities are producing the first glimmerings of international coordination of education.

We shall now discuss in turn each of these levels of living systems involved in education of less developed countries, applying the concepts outlined in Chapter I.

## 2. Level of the Organism:

## The Persons in the Educational Process

The central person in all of education is the student. During the time he is studying, at school or elsewhere, the needs of his matter-energy processing subsystems must be provided for--food for his ingestor; clothes and heat on his boundary to warm all his subsystems; lavatories for his extruder; walks, hallways, and exercise facilities for his motor. There must be facilities for his information processing subsystems as well--classrooms for discussions, recitations, and lectures, and to the extent they can be afforded, artifacts such as books, television, computerized programmed instruction, and audiovisual aids for his input transducer, which sends information over his channel and net subsystem to his associator; language teachers and language laboratories for his decoder and encoder; academic advisers and counselors on personal problems to transmit information over his input transducer and channel and net to his decider; classrooms, auditoriums, and speech laboratories for his output transducer.

Students are of different types--males and females, children and adults, all races, and many genetic strains. Their different physical, mental, emotional, and motivational characteristics mean that they have various needs which often are best met by individualized attention. Being human, students have highly complex nervous systems, decisions being made at several neural echelons, from the local adjustment processes of the spinal cord up to the subtlest creative processes of the cortex of the brain. As he matures each student must learn from his parents and teachers how to govern or control (a) his subsystems and components, his viscera and other organs (Freud used the term "id" to refer to such governance and the emotions and motivations related to it); (b) his entire system (Freud's "ego"); and (c) his system in relation to other persons in his suprasystem (Freud's "superego.") He must also learn how to use the common as well as the new and sophisticated artifacts which are becoming more and more important in our modern technological society. No education deals with the whole student unless it relates to his mental, emotional, motivational, physical, social, cultural, and technological adjustments.

Education is primarily an information processing activity of the student, involving many, and often repeated, information inputs to him and outputs from him as well as much internal processing in his nervous system. Thus he learns to use language, think, solve problems, make decisions, and adjust to the threats and stresses of life. Education involves learning many facts but it is more important for the student to discover where to find facts and how to make the adjustments required by a wide range of threats and stresses. One of the things that every educated person must learn, in one set of terms or another, is that adjustments are more adaptive if they are continually subjected to checks in order to discover whether they are optimally achieving their goals. This is accomplished by using negative feedbacks. A soprano checks her tones by playing back a tape recording she has just made. A student checks his progress by the monthly grades on his report card and, if he is motivated, works harder in those classes where he got the lowest grades. An athlete considers his previous year's batting average in deciding whether to try to make the baseball team again this year.

Even in early childhood students begin to learn about power--how to influence others to do what they want of them. This is a fundamental part of life. A person usually exercises power to accomplish his own goals which are established in terms of his long-run purposes. All of this relates to the most intimate aspects of his personality, his motivations, and his hierarchy of values. These are commonly learned more from informal and extracurricular personal interactions with parents, teachers, and fellow students than in the classroom. There is no indication that television or the computer or any other innovation of educational technology can in the foreseeable future substitute for this personal touch. Any educational system whose size or organizational arrangements makes such human contacts infrequent cannot accomplish one of its central missions. Anonymity is not the optimal climate for learning.

The individual student profits if, sometime in his education, he becomes proficient in taking an economic approach to the planning of his life. He must learn to husband scarce resources--friends who can help him, his own time and money, and useful materials and services. He must learn that for every benefit there is a cost and that it is to his advantage to optimize the trade-offs of costs and benefits. This makes for efficiency of personal decision making. Of course few human decisions are made by quantitative calculations. Often their bases cannot even be stated. But in actuality many personal decisions, especially major ones, involve cost-effectiveness evaluations. Education can develop a student's skills in making such evaluations.

Thus a student may be viewed as a living system, as can his family, his teachers and friends, and the other persons concerned in his education. Ordinarily, major purposes and goals of all these are altruistically centered on helping the student in his learning process. But they are all human beings intent also on achieving their personal purposes. Otherwise there would not be teachers' unions; otherwise some parents would be more willing than they are to help their children with their homework. Anyone who wishes to understand education or any other social process must recognize that every human being tends to optimize the achievement of his own purposes and goals and these cannot all be altruistic. Fortunately for students, many of them are.

## 3. Higher Levels of Educational Systems

Table 2 identifies the critical subsystems of educational systems (see Table 1, page 37) at the levels of the group (a class), organization (a school), society (a national formal and nonformal educational system), and supranational system (an international system for sharing resources among countries for formal and nonformal education).

Table 2

| Level / Critical Subsystem | Group<br>(Class) | Organization<br>(School) | Society<br>(National Formal and Nonformal Educational System) | Supranational System<br>(International System for Sharing Resources Among Countries for Formal and Nonformal Education) |
|---|---|---|---|---|
| Reproducer | Parents of students, teacher, or paraprofessional; teacher, paraprofessional, or students who set up class organization and procedures; artifacts such as writing materials for writing these down | City planning committee for new schools; artifacts such as writing materials for writing plans, procedures, regulations | Writers of charter of national educational system; persons or groups who initiate nonformal educational systems; artifacts such as writing or printing materials for recording charter | Persons, groups, or organizations from two or more countries who devise charter for the international educational system; artifacts such as writing or printing materials for recording charter |
| Boundary | Teacher that keeps out of class persons who do not belong, admitting only class members; teacher who decides what the class shall and shall not read; artifacts like classroom walls, doors | Guards, janitors, police; artifacts like walls, gates, fences | Security guards, national police, educators who travel abroad; artifacts like walls, gates, fences | Security or international system; persons, groups, or organizations who bring information to it from nonmember countries; artifacts like walls, gates, fences |
| Ingestor | Person who brings food or drink for class students; person who brings other supplies, furniture, or appartus; person who provides heat or light; person who recruits students, teachers, or paraprofessionals; artifacts like area of classroom around door | Persons at information desk; principal or teachers; admissions office; personnel office; electrical and heating engineers; receiving room personnel; artifacts like lobby of school, information desk, receiving room | Persons, groups, or organizations that receive supplies, furniture, equipment, or heat, light, or electricity for national educational system; persons that recruit personnel and students; artifacts they use, like vehicles | Persons, groups, organizations, or societies that receive matter-energy or recruit personnel to staff the system or receive students; artifacts they use, like transportation facilities |
| Distributor | Teacher, paraprofessional, or student who passes out supplies, food, or drink to others in the class, arranges furniture, or seats new students; artifacts like aisles in classrooms | Buildings and grounds and maintenance departments; electrical and heating engineers; busboys; food handlers; artifacts like school hallways, passageways, stairs, elevators, conveyor belts, electrical wires and fuse boxes, steam pipes | Persons, groups, or organizations that distribute educational supplies and equipment, including instructional aids, as well as educators and students throughout national system; artifacts like trucks, railroads, airplanes, and other means of transportation used for such purposes | Persons, groups, or organizations that distribute educational supplies and equipment, including instructional aids, as well as educators and students throughout the international system; artifacts like airplanes, ships, and other transportation facilities used for such purposes |

Table 2
(cont.)

| Level<br>Critical Subsystem | Group<br>(Class) | Organization<br>(School) | Society<br>(National Formal and Nonformal Educational System) | Supranational System<br>(International System for Sharing Resources Among Countries for Formal and Nonformal Education) |
|---|---|---|---|---|
| Converter | Teacher or other person who makes sandwiches for students, prepares reagents for a chemistry demonstration, cuts wood or metal for equipment, or cuts firewood; artifacts such as tools used to do these things | Cooks, electrical and heating engineers; artifacts like stoves, cooking utensils, tools, heaters | Persons, groups, or organizations that generate electricity, refine oil, or prepare raw materials for educational equipment and buildings to be used in the system; tools, machines, and other artifacts used in such converting | Persons, groups, or organizations that generate electricity, refine oil, or prepare raw materials for educational equipment and buildings to be used in the system; tools, machines, and other artifacts used in such converting |
| Producer | Teacher or other person who makes or repairs equipment, or who performs a chemistry experiment or cooks food for the class; teacher or paraprofessional who gives first aid to student; artifacts used to do these things, such as tools, bandages | Cooks; school nurses; maintenance personnel; artifacts like stoves, cooking utensils, tools | Persons, groups, or organizations that manufacture or maintain educational equipment and facilities for the system; nurses and doctors in system; artifacts such as manufacturing machines, tools, or medical supplies used for this | Persons, groups, or organizations that manufacture or maintain educational equipment and other facilities for the system; artifacts such as manufacturing machines, tools, or medical supplies used for this |
| Matter-Energy Storage | Person who stores educational equipment, or supplies of food, fuel, or first aid supplies; artifacts such as closets, cupboards, or bins for such storage | Storekeeper who stores supplies and food; nurse who stores surgical equipment; maintenance and buildings and grounds staffs that store general equipment; artifacts like closets, store rooms, shelves, containers, parking lot | Persons, groups, or organizations that store supplies, equipment, fuels, electricity, and other essentials for the system; warehouses, tools, storage rooms, batteries, and other storage artifacts | Persons, groups, or organizations that store supplies, equipment, fuels, electricity, and other essentials for the system; warehouses, tools, storage rooms, batteries, and other storage artifacts |
| Extruder | Person who carries waste or trash out of classroom; person who directs or forces a student or someone else in classroom to leave; teacher who passes or fails student so he or she leaves class; artifacts like waste basket | College officials who graduate or fail students; persons who put out garbage or trash; maintenance men; artifacts like trash or garbage cans, brooms, dump trucks | Persons, groups, or organizations that dispose of wastes, trash, sewage and garbage of the system; that remove persons from its buildings, discharge employees, that graduate or fail students; artifacts like vehicles, sewers, smokestacks, and other equipment used for this | Persons, groups, or organizations that dispose of wastes, trash, sewage, and garbage of the system; that remove persons from its buildings, discharge employees; that graduate or fail students; artifacts like vehicles, sewers, smokestacks, and other equipment used for this |

Table 2
(cont.).

| Level<br>Critical Subsystem | Group<br>(Class) | Organization<br>(School) | Society<br>(National Formal and Nonformal Educational System) | Supranational System<br>(International System for Sharing Resources Among Countries for Formal and Nonformal Education) |
|---|---|---|---|---|
| Motor | Person who transports class to or from classroom or moves it to some other location; bus or other artifacts used to convey the class | Drivers of college buses or trucks; artifacts such as cars, buses, trucks | Persons, groups, or organizations that operate vehicles used by system to move facilities or components of system; airplanes, ships, trucks, railroads, or other artifacts used in such movements | Persons, groups, or organizations that operate vehicles used by system to move facilities or components of system; airplanes, ships, trucks, railroads, or other artifacts used in such movements |
| Supporter | Persons who build and maintain the classroom and its furniture; artifacts such as the room itself and its furniture | Construction workers who build or alter school buildings, or landscape its grounds and build its walks and roads; artifacts such as school buildings and grounds, walks, roads | Persons, groups, and organizations that build and maintain buildings, platforms, and other facilities as well as maintain its land; artifacts such as tools, machines used in these processes | Persons, groups, and organizations that build and maintain buildings, platforms, and other facilities as well as maintain its land; artifacts such as tools, machines used in these processes |
| Input Transducer | Teacher, paraprofessional, or at times student who brings information to class in spoken or written form; artifacts such as books, journals, radio, TV, or equipment of other media that input information | Guards, telephone operators, mail clerks, public relations office; board of trustees; administrators; faculty members; students; library acquisition staffs; collectors of tuition and fees; artifacts such as mail boxes, telephone equipment, TV and radio receivers; cash boxes, safes | Persons, groups, or organizations that bring into system educational and curricular information, facts about the nation and the entire world; artifacts for conveying or receiving such information, such as books, journals TV and radio receivers | Persons, groups, and organizations that bring into system educational and curricular information, facts about the supranational system and the entire world; artifacts for conveying or receiving such information, such as books, journals, TV and radio receivers |

Table 2
(cont.)

| Level / Critical Subsystem | Group (Class) | Organization (School) | Society (National Formal and Nonformal Educational System) | Supranational System (International System for Sharing Resources Among Countries for Formal and Nonformal Education) |
|---|---|---|---|---|
| Internal Transducer | One or more members of class who are spokesman for some or all students, reporting what they feel, think, or are doing; artifacts like writing materials used to make such reports | Persons or units of school which make reports to supervisors; committees of students, teachers, and administrators; department heads; bookkeepers, controller's office, payroll department, accountants; artifacts such as computer used for compiling management information, business machines, telephones, typewriters, other writing materials, closed-circuit TV, time clock, suggestion box | Persons, groups, and organizations that make reports to superiors about internal affairs of system; persons providing feedbacks from students and teachers on system operations; regional delegates who vote on system; artifacts such as computers used for compiling management information, business machines, telephones, typewriters, other writing materials | Persons, groups, and organizations that make reports to superiors about internal affairs of the system; feedbacks from students and teachers on the system's operations; national delegates who vote on system policies; computers used for compiling management information |
| Channel and Net | Each group member who communicates with one or more other members by speech, gesture, or writing; artifacts such as audiovisual aids, books, slide projectors, paper, pencils, pens, chalk, blackboards, used in this communication | Administrators; telephone operators; communications maintenance men; secretaries; faculty and staff members; students; artifacts like books, slide projectors, paper, pencils, pens, chalk, blackboards, telephones, closed-circuit TV | Persons, groups, or organizations that operate and act as nodes in national communications facilities used for educational purposes, such as the mails, radio, TV, telephone, banks and financial institutions; artifacts used in such processes, like wires, cables, satellites | Persons, groups, or organizations that operate and act as nodes in international telecommunications used for educational purposes, such as the mails, radio, TV, telephone, telegraph, international monitary exchanges; artifacts used in such processes, like wires, cables, satellites |
| Decoder | Person who translates from one language to another, or from written to spoken speech or vice versa, or explains meaning of words; artifacts such as dictionaries that assist decoding | Persons who prepare reports on technical and other difficult topics, putting their contents into simple terms for students or others; persons who translate from one language to another; artifacts such as dictionaries | Persons, groups, or organizations that translate educational materials and communications from one language to another, or into simple terms | Persons, groups, or organizations that translate educational materials and communications from one language to another, or into simple words for students or poorly educated; artifacts like writing equipment used for this purpose |

Table 2
(cont.)

| Level / Critical Subsystem | Group (Class) | Organization (School) | Society (National Formal and Nonformal Educational System) | Supranational System (International System for Sharing Resources Among Countries for Formal and Nonformal Education) |
|---|---|---|---|---|
| Associator | Students who learn to combine bits of information into knowledge or skills; teachers or paraprofessionals who help them or who learn how best to arrange class procedures; artifacts like books, journals, projectors, teaching machines, TV sets, computers, computer terminals used in such associating processes | Administrators, curriculum planners, teachers who assist students in learning or develop school procedures; artifacts like books, journals, projectors, teaching machines, TV sets, computers, computer terminals used in such associating processes | Officials, groups, or organizations that learn from previous experiences of system and feedbacks from its components and environment, and consequently alter its structure, policy, and procedures | Officials, groups, or organizations that learn from previous experiences of system and feedbacks from its components and environment, and consequently alter its structure, policy, and procedures |
| Memory | Teachers, paraprofessionals, students, who remember information; artifacts that store information such as books, journals, maps, pictures, charts, files | File clerks, bookkeepers; secretaries, librarians; computer experts; artifacts that store information such as books, journals, maps, pictures, charts, files, libraries, data banks, computers | Persons, groups, or organizations that maintain for the system archives, files, libraries, data banks, sets of instructional materials, or who remember facts relevant to the system; artifacts they use, like files, books, journals, book shelves, computers | Persons, groups, or organizations that maintain for the system archives, files, libraries, data banks, sets of instructional materials, or who remember facts relevant to the system; artifacts they use, like files, books, journals, book shelves, computers |
| Decider | Teacher, paraprofessional, and in some classes, student or students who determine what the class does; artifacts such as pencils, pens, paper, chalk, blackboards used by teacher, paraprofessional, or students in decision-making processes | Board of trustees; principal; department heads, some students, secretaries, staff members; artifacts such as writing materials, blackboards, chalk, computers, calculators, abacuses | System executives and their staffs; policy-making boards and committees; also may be decentralized to teachers and other personnel in system throughout the country | System executives and their staffs; international representatives, policy-making boards and committees; also may be decentralized to teachers and other personnel in system in different countries |

Table 2
(cont.)

| Level / Critical Subsystem | Group (Class) | Organization (School) | Society (National Formal and Nonformal Educational System) | Supranational System (International System for Sharing Resources Among Countries for Formal and Nonformal Education) |
|---|---|---|---|---|
| Encoder | Teacher, paraprofessional, student or students; artifacts such as dictionaries, pens, pencils, paper, other writing materials | Chairman of board of trustees, principal, department heads; some teachers; artifacts such as dictionaries, paper, pencils, pens, typewriters, duplicators | Persons, groups, or organizations that prepare official publications and reports of the system, like catalogs; writers who prepare speeches for spokesmen; spokesmen and public information officers; artifacts they use, like paper, duplicators, typewriters | Persons, groups, or organizations that prepare official publications and reports of the system, like catalogs; writers who prepare speeches for spokesmen; spokesmen and public information officers; artifacts they use, like paper, duplicators, typewriters |
| Output Transducer | Teacher, paraprofessional, student or students or graduates of class who make written or oral reports for or about the class; artifacts like typewriters, public address system, paper, pens, pencils | Educational administrator, teacher, or other spokesman who speaks officially for the school; business officer that pays its bills; graduates of school; artifacts such as typewriters, microphones, radio or TV equipment, public address system, printing presses, duplicators, mailing equipment used in making or issuing reports | Spokesman for national system, such as Minister of Education; operators of educational broadcast media; typists and printers who put out reports from system; graduates from system; artifacts like TV equipment, printing press, microphone, journals used in making reports | Spokesmen for international system; operators of international educational broadcast media; typists and printers who put out reports from system; graduates from system; artifacts like TV equipment, printing press, microphone, journals used in making reports |

Table 2. The Educational System (*i.e.*, Associator Subsystem) of Each of Four Levels: Group (a Class); Organization (a School); Society (a National Educational System); and Supranational System (an International Educational System).

## 4. Level of the Group:
## The Class or Tutorial Session

Ordinarily the fundamental educational process is face-to-face--the simplest form being the tutorial relationship of one teacher or counselor and one pupil, Mark Hopkins on one end of a log and the student on the other. More typically there is one teacher and 20 to 30 students, a classroom. The classroom is made of walls, floors, and ceilings, material artifacts which constitute the supporter subsystem of the group who study in it. In and out of the classroom matter must flow--students, teachers, school books, the hardware of audiovisual aids, other supplies--and so must energy--heat and light. These flows change over time. But the most important flows in a classroom are information flows--the information in the books, on the television sets, and in the interactions between the students and the teacher. These information transmissions are integral to the fundamental learning process. They also are the means whereby the teacher maintains discipline and coordinates the students who are components in the concrete living system which is the class.

The spatial structure of the class importantly influences its processes. If students are seated at desks facing the blackboards or television set, their interactions are different than if they are arranged in a circle or if they are stationed at laboratory benches. The classroom process varies also with the content of the information discussed and the teacher's approach to interpersonal reactions, which is often dictated by the teacher's philosophy of education.

Group learning situations differ in type: some are lecture sections, some discussions, some laboratories, some field trips, and some are extracurricular or nonformal groups. The typical class is a face-to-face group and so it does not have echelons, but occasionally a large class organizes into echelons. The suprasystem of the class is an organization, the school, and its subsystem is the individual student or teacher.

Within the class there are numerous sorts of transmissions. Matter-energy such as laboratory equipment, experimental animal or chemicals may be distributed to all the students. Information is processed when the teacher asks questions and the students respond, when the teacher writes problems on the blackboard and students solve them on their papers.

Also various sorts of steady states are maintained by the class. Ordinarily the teacher exerts the dominant control of these. With the help of the bell and the clock which signal the times for class periods, the teacher determines when the class begins and ends. The teacher usually divides the time available to the class more or less equally among the students, recognizing who is to speak, keeping the entire class in adjustment by urging some students to talk more and quieting those students who speak too much or out of turn.

Often the teacher varies the rate of information processing, sensitively reacting to signals in the students' expressions and comments, which indicate how fast and well they are learning. A new topic is not taken up until most of the class have mastered the previous one.

Usually the teacher wields the primary power in the class, but often, as the students get older and enter the higher grades, this power is diminished. Sometimes students resolve conflicts among themselves, but often the teacher must step in as the decider in the group. The teacher is trained to understand the overall purposes of the course being taught and to set day-to-day and moment-to-moment goals to accomplish these purposes.

Of course there are significant costs in the functioning of any class. First there are the original capital costs of building the classroom. There are the operating costs of light, heat, supplies, and repairs. There are also the costs of recruiting, training, and equipping the teacher and of the information-processing media which bring information to the class. There is the salary of the teacher and any paraprofessionals, administrators, or staff. Besides the money expended there are also costs in human time which is spent at the school. Since it is possible to evaluate, at least roughly, the effectiveness of a single hour in class or a single course, cost-effectiveness evaluations of a specific class are possible.

What are the critical subsystems of the living system known as the class? The student who holds open the classroom door so others can enter or goes out to call in his fellow students at the beginning of class is part of the ingestor. The teacher or child who distributes fruit or milk in kindergarten is part of the distributor. The assistant responsible for the stock of glassware and chemical reagents in a high school laboratory is part of the matter-energy storage subsystem. The student who opens a window or door when the class gets too hot is part of the extruder.

The information processing subsystems are more central to the main purposes of any educational group. The child who comes in and reports on his experiences over the weekend in "Show and Tell" is a component of the input transducer. The girl who reports that the boy behind her is sticking her with a pencil is part of the internal transducer. The channel and net includes air through which the students talk as well as the examination papers they hand in to the teacher. Often the teacher alone is the decider, but at times some or all students may join with the teacher in this group process. The report from the teacher to the principal on how the class did that week is an output transducer function.

All the above concerns formal educational groups. More education is nonformal than formal. In a few cases nonformal education may occur in groups, as in families, youth groups, or community groups in a village square. Such groups make some sort of rough delegation of functions like those of traditional classes, but their structure is more changeable and looser. Those with access to the information, the older or more experienced, in general control the group and inform the younger or less experienced. Much nonformal education, of course, goes on in individual persons working independently.

## 5. Level of the Organization:
## The School, College, or University

5.1 The school. A school is a system whose components or subcomponents are classes in classrooms, administrators in offices, workers in storage areas, cooks and waitresses in cafeterias, and maintenance personnel throughout. It is usually part of a school system, which is its suprasystem.

Schools are open systems into which resources and people--students and employees--come and from which students graduate and the employees leave after a period of time. The processes which a school purposes to bring about are irreversible learning processes. A school is in some ways like a job shop in which students are processed from station to station, from one learning experience to another. The experiences of various students are similar but not identical. Nor are their order and timing identical. If a school succeeds in individualizing instruction, a student's behavioral and cognitive changes are the key determiner of the timing.

A school is generally housed in a supporter subsystem artifact--a building or a set of buildings on some real estate, all together occupying physical space. This physical space is important because it limits expansion and restricts the size of auxiliary facilities such as football fields and playgrounds. Building a school alters arrangements in physical space, but it also changes the spaces of abstracted systems in which it is located, _e.g._, community structure or relationships. It becomes the locus of many community activities, such as the Parent-Teachers Association which allow citizens to cooperate for the purpose of helping the school. It allows certain members of the community to exercise initiative and leadership and derive a variety of benefits from that kind of participation. It also becomes the center of a political unit for those persons who are concerned with financial and other support of that school. It affects real estate values in its immediate surroundings.

Time is a fundamental dimension in schools. In some an established procedure of ringing bells divides time into regular segments and indicates the limits of class periods. The class programs and major activities are scheduled in terms of the days in a school year calendar. One recent change in many schools has been flexible scheduling, based on the developments in individual classes. The availability of media, the use of closed circuit and broadcast educational television has added more flexibility to some aspects of school processes but more rigidity to others which are dependent on the timing of broadcasts. The more individualized instruction with books, cassettes, or dial-access tape laboratories that is available, the more flexible can the scheduling and operation of the school be.

In common with most other organizations schools process matter-energy. As any school principal knows, planning about matter-energy structures and processes comes first whenever any new school is being constructed. The architect designs the walls, floors, roof, and other parts of the building and the contractor constructs it from those plans. Fuel is commonly brought in to provide heat when it is cold and, in some parts of the world, electricity to provide light and power. There are also often inputs of water, food, equipment, and other supplies and outputs of garbage and sewage. Over time students come and students go.

Information transactions, however, are the main business of a school. In addition to the direct information interactions which occur between teacher and student, the administration and operation of the school as a whole require many types of information flows. Operational information is needed to coordinate and plan the educational process. Information is collected on such matters as pupil attendance. Such data are important as operational indices and for fiscal and administrative purposes, since in many schools, the amount of revenue received depends on them. Payroll information must also be collected. Additional information is necessary for scheduling programs of students, teachers, and facilities.

All the variables in a school are never in steady state. Adjustment processes reacting to negative feedbacks are continuously active. Feedbacks occur within the school in many channels between the principal, the teachers, and the students, as well as the parents and the citizens of the community. Numerous adjustment processes are required to keep the school operating under these many forces.

In one-room schools the teacher is the chief decider. In larger schools power and conflict are critical problems. In many of them today, decision-making power is chiefly wielded by the teachers. The principals or other administrators are faced with the difficult position of being expected to resolve conflicts and bring about decisions to keep the system integrated, which concern teachers, over whom they have little control because of their tenure, teachers' unions, schoolwide curricular decisions, and a suprasystem which makes the decisions allocating major resources. Often the principal feels that he is little more than the school's output transducer--a public relations man. Of course, in small schools, or independent ones, the principal or headmaster may be the key power figure. Conflicts also occur between outside and inside groups such as unions and faculties. Conflicts also occur inside schools between students and teachers. Interpersonal conflicts within the staff have always existed.

The purposes and goals of a given school relate to the overall plan of its suprasystem, the school system. Individual schools are expected to apply their resources to maximize the educational objectives set forth by the school system. Typically these purposes and goals, of quite different sorts, may be divided into: (a) educational objectives, such as preparing a student for a vocational school, teaching vocational skills, preparing a student for college; (b) social skills, such as good citizenship, developing good consumers and responsible citizens; (c) economic service objectives, such as keeping the students off the streets, babysitting for working mothers, and other such activities; and (d) community services, such as PTA or nonformal educational programs in the late afternoons or evenings, and weekends. The physical plant is often used by the community also, for recreation and entertainment, for sports, movies or plays.

Costs of a school include use or expenditure of scarce resources such as materials--foods, equipment, supplies; energy--light, heat, fuel; information--books, audiovisual and other instructional aids; budgeted funds; human time of all personnel in the school and many in the community. When these inputs are measured and compared with output measures of achievement of purposes and goals, cost-effectiveness evaluation of a given school is at least roughly possible. Effectiveness can be measured in terms of the number of students who graduate, the number who go to college, the number who drop out, how well students do in competitive examinations, how well they do in getting and holding jobs, measure of changed attitudes and behavior, crime rates among students and graduates, and other indices of undesired social conditions among them, such as narcotics addiction, ill health, or poor housing.

The critical subsystems of a school may include guards who protect and maintain the boundary; the admissions office whose personnel register new students and so are components of the ingestor; workmen who cart equipment to various rooms in the school, parts of the distributor; the cooks in the cafeteria, components of the converter and the producer; the bookstore clerk, part of the matter-energy storage subsystem; and the janitor, a component of the extruder. As to the information processing subsystems, the student, teacher, or the technician who operates the educational television controls is a unit of the input transducer; the teachers, paraprofessionals, administrators, and students all participate in the channel and net; the librarian is part of the memory; the principal and teachers jointly constitute the decider, with the principal more in control in some cases and the teachers more in control in others; and the principal and often the teachers are major components of the output transducer.

5.2 The college. A college is a concrete living system with a structure usually clearly pictured in maps of the college. The process in that structure is often vigorous and always complex.

There are various types of colleges, classed by the content they study--*e.g.*, general education, engineering, or law--by number of components, and by form of organization. The suprasystem of some colleges is a university. For independent colleges it is the community of which they are a part. The components are departments, usually representing separate academic disciplines, and other units such as student unions, fraternities, dormitories, and field stations.

A college has as its territory the campus. Within its boundary are arranged clusters of matter which are its buildings. Into this campus enter many forms of nonliving and living matter--bricks and mortar, furniture, equipment, supplies, food, automobiles, bicycles. Also animals and human beings enter. And there are outputs of such things as well; some, like the graduates, are the products of the system. Others are wastes. All the structural configurations and processes of input and output change over time. This change may be slow, for many colleges are traditional. They often endure a long time. Some European colleges are centuries old. Even in America Harvard College has lasted more than three centuries and Yale for nearly three.

As at all other levels of educational systems, the types of processes which are most important and characteristic and which chiefly accomplish the purposes and goals of the system are the information processes. Information flows into a college from all over the world--by scholarly journals, books, radio, television, the mails, but also by visiting scholars, students, and others who come there for varying lengths of time. There are many patterns of information communication and storage within the system. These include interactions among students and faculty, learning by faculty and students, storage of memories in human beings and libraries, and publication of knowledge through books, broadcasts, and travel of professors and graduates to all parts of the world.

Some colleges, like a Jesuit seminary or a school of agriculture and mining, are quite clear about their purposes. Others, particularly those concerned with general education and the humanities, are less certain. Nevertheless, they appear to set goals which lead toward certain purposes, vaguely or clearly outlined.

Any faculty member or administrator of a college who has ever made a budget knows that all the college's processes involve costs in matter-energy, information, and time of the human beings involved. Consequently it is possible to make cost-effectiveness evaluations of how well the system is achieving its long-range purposes and its short-range goals. The measurement of effectiveness of such a system is by no means easy because the organization's purposes and goals are subtle. Much thought has been given to this problem of evaluation, however, and this effort has resulted in some progress.

It is not hard to identify the critical subsystems of a college. The police who guard it are involved in its boundary subsystem. Those who bring in the necessary books, supplies, fuel, and food are parts of its ingestor, and the drivers of the delivery trucks and porters who take such things to all parts of its campus are components of its distributor. In closets, pantries, and bookstores it has matter-energy storage. The cooks, heating engineers, and carpenters are components of its converter and producer. The drivers of the trucks that remove the wastes are parts of the extruder.

In the information processing subsystems the Dean of Admissions and the mail clerks are parts of the input transducer. The Dean of Student Affairs does much of the internal transducing, learning how the students feel about various aspects of their college life. Both students and teachers are involved in learning and are components of the associator. The scholars and librarians are parts of the memory. The department chairmen, deans, and presidents help to make up the decider. The administration of the college uses its power to maintain the appropriate adjustments between the students' demands for power and accomplishment, the faculty's demands, and the demands of the other components in the total system. The officers of administration constitute a major component of the decider, which may often be dispersed to include others as well. They make their decisions in the light of many feedbacks which they receive from all parts of the system and its environment. Often they find themselves involved in the resolutions of interpersonal and intergroup conflicts.

The administration also is a chief component of the output transducer. With cooperation of many other components, it maintains a steady state relationship between the system and the suprasystem, through public statements and press releases, and various interactions with the alumni and citizens of the community. The faculty who publish and go forth to lecture, as well as the trustees, are also components of the output transducer.

Nonformal higher education by correspondence courses, home study, and television has expanded as the concept of lifetime learning has received increased currency in both established and less developed countries. This is conducted in a more flexible structure than that of a typical college described above. Students of all ages are accepted; prerequisites are often waived; examinations sometimes replace courses; students do not follow fixed time schedules. But the processes of the system are in other ways usually much the same.

5.3 The university. Obviously a university is not fundamentally different from a college as a living system. It is usually larger, more variegated, more sophisticated. Because of their size and variety, as universities have grown from colleges they have developed more and more echelons. Some colleges have only department chairmen and a president. But long ago deans intervened over department chairmen, and in the last 20 to 30 years provosts, chancellors, vice chancellors, and vice presidents have also flourished. Academic structures have become much more complex with components, subcomponents, and subsubcomponents--colleges, departments, and units of departments, as well as institutes, centers, and intercollege programs.

As the systems have grown in size and complexity, decision processes have been decentralized and the systems have demonstrated less integration. The major programs or components usually represent content areas or disciplines--categories of information processed--instead of functions, which components almost always represent in large industrial or governmental organizations. Although the boundaries of university departments at first are often set by subtle academic logic, and so surround abstracted systems, eventually the different components so separated grow into semi-autonomous concrete systems--groups of people.

Management information systems are being used for the first time in recent years to evaluate the cost and effectiveness of programs of higher education. The costs are easier to determine than the effectiveness, but to some extent arbitrary criteria have been set up, like the national ratings of the quality of graduate departments, the number of their publications, or the number of their graduates who pass professional examinations. These measures, though subject to criticism and clearly unsophisticated, are first steps toward more reliable effectiveness evaluation.

The critical subsystems of universities are similar to those of colleges. The main difference is that the decider subsystem is much more decentralized.

Nonformal education is beginning to flourish around the world in universities as well as colleges. The British Open University, imitated in several other countries is the paradigm.

## 6. Level of the Organization (Higher Echelons): The School System or Statewide Educational Agency

The structure of a school system or statewide educational system is much more complex than that of a school, college, or some universities. Some decisions are centralized and others are decentralized. Some very large systems have several hierarchical echelons. The processes involved are those of planning, control, training, logistics, acquisition of educational materials, and development of common services to serve all components of the system.

The suprasystem is the community or the state. Altogether these higher echelon educational organizations constitute a major part of the associator subsystem of the community or state--at least the formal part of it.

The matter and energy of a school system or statewide educational agency include all matter-energy in the organizations which are its components and their artifacts. In addition there are school bus transportation facilities, warehousing and shipping facilities, and other services which use the roads of the community or state, which is the suprasystem of the system. Time takes a new perspective as compared with the school's time units of hours, weeks, and the school year. A school system works in terms of several years. A bond issue or a governmental appropriation and a consequent commitment to buy land and build on it is a multiple-year activity. Planning-programming-budgeting (PPB) for school systems always requires a multiple-year plan.

Information processing also is essential if personnel, facilities, and allocated resources are to be kept under control and coordinated. Resource allocation and control are major functions of a school system or statewide educational agency. Individual institutions in the system need monetary inputs and generate the flows of administrative information that lead to more such inputs. The school board, state secretariat of education or regents, with their ability to propose bond issues and to request or help determine tax levies, gets involved in many political processes in the decider subsystem of the community or state. All these processes must be coordinated by information flows into and out of the system.

There are matter-energy flows of supplies and equipment and of persons among components of school systems or statewide educational systems. Information flows, usually over the community channel and net subsystem, are much more fundamental. They provide feedbacks and control signals which maintain the adjustment processes that keep components of the system in steady states in relation to each other and to the rest of the community or state. Information is processed about votes and bond issues, levies, the effect of the press, and public sentiments about the educational system. Many school systems have shown great interest in developing instruments to measure how they are viewed by the public (input transducer activity) and in public relations (output transducer activity).

Power and conflict problems are much greater in the school systems (or statewide agencies) level than in schools. Internal discussions about such systems also intimately involve issues of power in the suprasystem of which they are a part--community and state governments, citizens' groups, real estate interests, and political organizations, among others.

The purposes and goals of a higher echelon education system are ordinarily expected to be achieved over a longer time span than purposes of a school. Five years is the minimal planning period for the education of a cohort of students in established or less developed nations. Often it is ten years or more. A time span of seven years is minimal for such planning as the decision to buy buses, because seven years is the average life of school buses. Land buying commitments involve planning many years ahead, since bond issues or public financing may take 20, 30, or 50 years to retire.

The purposes of such educational systems include giving quality education to all citizens through programs which meet their individual needs, including special groups like illiterates, children with physical disabilities or learning disabilities, adults who have dropped out of school or who have not learned an occupation. These purposes may be achieved by accomplishing specific goals like operating special education classes, an educational television station, a vocational school, or a nonformal education program for illiterate adults.

Cost-effectiveness evaluations are of great potential value to higher echelon educational organizations because a maximal possible level of expenditure exists at any given time, and the system should try to achieve the optimal ratio of costs and benefits for that level of resources. It is difficult to finance outstanding programs when inflation, increasing salaries, and other pressures exert continuing financial pressures on the system, sometimes even in spite of additional revenues. These problems may lead the system to develop a PPB accounting system. This can facilitate presenting program alternative with meaningful cost projects to the officials responsible for making decisions about the best allocation of resources to accomplish their goals.

The critical subsystems of a higher echelon educational system include: Guards and community police that protect the boundaries of its properties. Warehouse personnel that receive shipments of fuels, furniture, and equipment, components of its ingestor. Truckers who deliver such supplies to component institutions, parts of its distributor. Persons who build or manufacture supplies, part of its converter and producer. Warehouse laborers, parts of its matter-energy storage. And bus drivers, components of its motor.

Closer to the system's primary purposes are the subsystems that process information, including administrators who bring back from national or international conventions reports on what other similar systems are doing, components of the input transducer. Administrators who receive periodic reports from each institution in the system, part of the internal transducer. Telephone operators, parts of the channel and net. Filing clerks, parts of the memory. The board and top administrators, parts of the decider. And the chairman of the board or the chief administrator or public relations officer, parts of the output transducer.

## 7. Level of the Society:

## The Nation's Educational System

Countries vary greatly in the structures of their associator subsystem, made up of the components responsible for education. Formal education in most other nations, as we have noted, is much more centralized than in the

United States. The components of the elementary, secondary, and higher education of the United States have been described above. The national educational system is simply the sum total of these plus the administrators who determine policy for it, like the Office of Education, acting as interfaces between it and the total nation.

The national educational system of the United States has few operating units beyond those mentioned above. Consequently the main emphasis in discussing this level of national educational system will concern how decisions are made in it. Day-to-day decisions in individual schools of course are made by its principal and teachers. Superintendents in schools and boards of education are probably the most autonomous decision-making units in elementary and secondary education, just as college and university administrators and boards of trustees are autonomous decision-making units in higher education. State superintendents of education have been relatively impotent so far, and until the last few years statewide controlling boards of higher education have not been powerful deciders, but the balance of power is rapidly changing from the colleges and universities to the administrators of statewide systems, including the governor and the legislature.

The United States Office of Education has been relatively impotent until this decade, but its decision-making power has grown in the Kennedy, Johnson, and Nixon administrations. It is still much less influential in elementary and secondary education than in higher education, although the balance is shifting. The fundamental influence in the Office of Education is through the funds it administers for building construction, educational subsidies, student loans and grants, educational research, and educational technologies. As it gained this financial power the prestige and decision-making power of the national educational organization has increased dramatically. Through the networks of official communications channels and through professional conventions, local school boards and college boards of trustees are affected by national decision-makers. The granting processes of federal agencies and foundations have also become important aspects of the decision-making process. Now, for the first time, it begins to be possible to plan such institutions as national resource centers to provide curricular materials for various media, as well as national electronic networks for educational purposes. When these begin to function, not only decision making but also the education process itself is likely to become more centralized nationally.

The organization structure of most of the less developed nations is quite different. The Minister of Education usually has much more power to make policy and budgetary decisions than any federal official in the United States. The Secretaries of Education in the various states or regions are permitted some discretion under broad directives, and they in turn permit more restricted discretion to administrators at lower echelons of the national system. In some countries educational programs emphasize regional and local languages, customs, and cultures. In others such regionalism is muted by a strong emphasis on nationalistic educational themes.

In many less developed nations it is apparent that the formal educational system cannot in the near future begin to meet the educational needs of the children or the adults. Nonformal mass education, probably using the information processing technologies, appears to be the only feasible approach to a solution.

## 8. Level of the Supranational System: The International Educational System

Except for the interchange of publications among nations for Fulbright, Guggenheim, and other visiting fellowships and scholarships, the educational systems of the world's nations have been almost entirely independent of each other and still are. With the establishment of the League of Nations and more recently of the United Nations--and particularly with UNESCO related to the United Nations--there is some worldwide planning and mutual assistance for education. Several major nations and multinational agencies are providing financial aid and technical advice in this field to less developed nations.

Someday there may be an international or supranational educational system with a multinational decider, but we are far from it at present. Educators are communicating regularly by publications, international congresses, and international consultation. The educational leaders of nations know each other and intercommunicate to a degree. The first steps have been taken toward the development of international textbooks and television lectures, and the setting up by satellites of international channels and networks interconnecting the national educational systems of the world. There may well be rapid development of these technologies and consequently of the decision-making process required to coordinate them. As of now, however, the international educational system is not a true system, since there is no effective central decider. There are only vestiges which may sometime grow into a potent means for teaching the citizens of the world and hopefully aiding them to live together in harmony.

# CHAPTER III

# THE RANGE OF INSTRUCTIONAL TECHNOLOGIES AND PRIORITY RESEARCH AREAS RELATING TO THEIR POTENTIAL CONTRIBUTION TO EDUCATION IN LESS DEVELOPED COUNTRIES

What do we mean by instructional technology? In its broadest sense this phrase may refer to any form of learning situation planfully established by an educational system, including a tutorial session, a group conference, a school class, or a large university lecture, as well as the use of a wide range of man-made artifacts. Its more common usage includes all artifacts that aid in the learning process--from chalk to computers. The communication channels and nets which make possible widespread use of these technologies also should be included in any consideration of educational technology--word-of-mouth transmission in human interaction situations, transmission by courier, by the mails, or by telegraph, teletype, telephone, or television lines, microwave, laser, national or international communications satellite.

## 1. Comparative Evaluation of the Media

All evaluation of instructional technologies should focus on their service to the learner, their functions in the provision of a learning environment. The emphasis should not be on the teacher or the hardware. With this orientation we must evaluate all these technologies in terms of their comparative cost-effectiveness. Each of the technologies which have flourished so suddenly in recent years should be investigated as an available artifact that can serve as a prosthesis to aid the learning process (see pages 41 and 42). It is incumbent upon educators, with this new-found wealth of resources, not to continue traditional forms of instruction unless such evaluations of their cost-effectiveness demonstrate them to be more useful and desirable than other available methods. We must ask what each method can contribute to improve education, or cut its costs, or both. Under what circumstances should one technology be employed rather than another? How does each serve to accomplish the long-range purposes or short-range goals of the system? Which contributes most to the individual organism in the educational system, to the group in the classroom, to the school or university as an organization, to the society's educational system, or to international educational activities?

Instructional technologies should generally be viewed only as adjuncts to human beings, rather than as substitutes for them. Over the centuries that man has used scrolls and books he has become accustomed to the idea that, at least in formal education, the book is an aid to the teacher or the professor, usually not a replacement. Apprehension about automation--replacement of the worker by the machine--which exists in many trades and professions today, appears to prevent educators generally from understanding that all the other instructional technologies should be used as books are. They are aids to the human beings involved in the educational process, primarily the students and secondarily their teachers. Radio, television, or computerized programmed instruction, for instance, may be able to provide or assist in some standard learning activities, or transmit information more rapidly and cheaply and to more people than human beings can. This should lighten the burden of the available educators so that they can then devote themselves to dealing with such matters as their students' motivation to learn; problem solving, using principles the students have learned in relation to real tasks in their own lives; students' manual dexterities; their attitudes and feelings about what they learn; ethical, moral, and religious issues; philosophical interpretations of the meaning of the knowledge; and other such concerns in which artifacts will quite possibly never replace human beings. Certainly such gifted hardware and/or software are nowhere on the horizon now.

Any educational innovation ideally should be employed, at first, in a situation which permits comparative, controlled, and hopefully continuing cost-effectiveness evaluations. Such evaluations should take into account various sorts of costs: in scarce forms of matter-energy including land, buildings, and hardware; in forms of information, including books, documents, programmed instruction, and other learning materials which are in short supply; in short-range and long-range expenditures of funds available for either capital construction or operations; and in the time of students, teachers, faculty, administrators, and service personnel (see pages 50 and 51). The costs of other related and essential activities must also be calculated, including research on the learning process, procedures for evaluating new technologies and instruction of teachers and other personnel on how to use the technologies. The fact that several quite different sorts of costs are involved complicates any cost-effectiveness.

Even more difficult is the problem of evaluating educational effectiveness. A number of criteria of effectiveness of instructional technologies have been suggested by the Subcommittee on Efficiency and Innovation in Education of the Committee for Economic Development:[1]

"Can the proposed technique be effectively employed in cultivation of an open, inquiring mind? Or does it tend to produce conformity, dogmatism, and regimentation of thought?

"Is it capable of communicating and facilitating an understanding of complex concepts? Or is its usefulness limited to the management and manipulation of simple ideas?

"Is it capable of cultivating sensitive insight, originality, analytical facility, and creative intellectual skills?

"Can it be employed to induce and deepen artistic and moral sensitivity and appreciation?

"Do the benefits gained justify the costs incurred? Is the initial cost affordable?"

Evaluation of educational benefits or effectiveness is unsophisticated and superficial unless it takes into account considerations like those above. But educational psychology and the other behavioral sciences have supplied us with few effective, reliable, and valid instruments to measure such subtle aspects of human behavior, personality, and social interactions.

We are, therefore, in danger of neglecting important variables in the educational systems we are evaluating because we do not have adequate ways to measure them.

## 2. Resistance to Change in Educational Methods

Any new instructional technology also should be evaluated in the light of a realistic appraisal of the sociological facts about man's resistance to change. Almost every important innovation in education, or any other field for that matter, has been resisted by people who are entirely satisfied wi[illegible] current state of things or who have entrenched interest in maintaining the present state because they would lose certain benefits, comforts, or sources of support if change occurred. When the horseless carriage appeared, the voices in the street cried, "Get a horse." When the Wright brothers first flew their plane, the voices proclaimed, "If God had meant man to fly he would have provided him with wings." The modern version of the last complaint is, "If God had meant us to fly without propellors, planes would have been designed with jets." Comparable attitudes toward new educational inventions are very common in all nations, established or less developed, among parents, teachers, professors, academic administrators, politicians, and policy-makers--even students themselves. Anyone who does not consider this social phenomenon in his attempts to employ and evaluate educational technology is neglecting a major factor. Strategies for introducing innovations must include plans for countering opposition to them.

## 3. The Central Social Issues About Education

Pressing social considerations demand that our concern for instructional technology be more than perfunctory. The rising costs per student of education and the increasing demand for it by the people of all nations face many less developed countries with nearly insolvable fiscal problems. The money required for the traditional modes of formal elementary, secondary, and higher education is more than the society can afford to pay. Furthermore, the quality of much present instruction is devastatingly low by any standards. Often provided by teachers who are themselves almost untrained and barely literate, it is limited, parochial, superficial, and frequently irrelevant to the life of the community. Inequalities of access to education throughout the population are directly related to social class, race, sex, and age differences. The dropout rate is so high that in some regions a majority of students do not go beyond first grade; in others most drop out after the third grade. Furthermore, nonformal education for adults is much less extensive than it might be. Yet, despite its great costs and its many problems, education is almost universally recognized as a necessity, the primary fashioner of a society's future. To the solution of many of today's overwhelmingly difficult national and international problems, it appears, more and better education is the prime prerequisite. This fact gives it its high priority among all of man s activities.

## 4. The Strengths, Weaknesses, and Costs of Various Instructional Technologies

Instructional technologies have been grouped by different writers in the field according to various rubrics. Three of these are:

(a) From the earliest to the most recent, beginning with purely human interactions such as tutorial sessions, discussions, and class lectures, and going on to use of simple artifacts such as placards with lettering or blackboards, and ending with computers, satellite transmitters, and videotape recorders.

(b) According to hardware and software properties of machine-based and nonmachine based technologies.

(c) By function--i.e., laboratories for language studies, computers for mathematical studies, TV and radio for mass instruction at a distance.

For our purposes, the first classification scheme seems to be particularly advantageous. A developmental analysis of instructional technologies seems intuitively relevant for application to less developed countries, as it suggests a sequence of events in established nations which may be quite fallacious--after all, parts of the world have gone directly from oxcart to helicopters. A developmental taxonomy, however, aids in posing this interesting issue clearly,

The list of instructional technologies which follows has been compiled from a search of the literature, ordered according to a taxonomy outlined by Schramm.[2] He classifies the media by generations.

First generation media. The earliest and most widely used instructional devices, which continue to dominate education, are included in this category:

tutorial session or small discussion group
class lectures
lettering
writing on blackboards
charts
diagrams
graphs
maps

stage scenery sets
written papers
demonstrations
dramatizations
exhibits
field trips

Second generation media. Included under this rubric are instructional technologies which make literacy and universal public education a reality, as consequences of the invention of the printing press and the resulting ease of dissemination and lowered production costs;

books
journals
newspapers
workbooks
comic books
tests
programmed textbooks

Third generation media. This group of instructional media encompasses the varied technologies which have arisen during the Nineteenth and Twentieth Centuries introducing machines into the communication process. As Schramm has noted, "For countries which are short of well-trained teachers and which face a need for widespread technical training, these third generation media, are, therefore, of obvious importance."[3] The use of TV and radio for instructional purposes characterizes this generation as the area of telepedagogy. Kenya, Niger, Nigeria, Ivory Coast, Samoa, Thailand, India, Peru, Colombia, Algeria, Togo, El Salvador, New Zealand, and Honduras are most often cited as the less developed countries who have made the largest investments in educational equipment of this generation. This generation of instructional technology, along with the fourth generation, are still so new that their full potential is as yet uncertain. The third generation list includes:

- photographs
- filmstrips
- teaching machines
- silent motion pictures
- filmstrips with audio tapes
- slides with audio tapes
- sound motion pictures
- telephone
- broadcast live instructional radio
- telewriting, telewritevision
- audio tapes
    - (a) reel-to-reel
    - (b) cassettes
    - (c) cartridges
    - (d) records
- dial-access audio tapes
- teletype
- telegraph
- closed-circuit audio lectures
- telelecture, radiovision
- slow scan TV
- live instructional TV
    - (a) broadcast
    - (b) closed circuit
- tape recorded instructional TV
    - (a) broadcast
    - (b) closed circuit
- facsimile transmission

Fourth generation media. This final group represents the most recent and sophisticated instructional technology available. The media in this category are distinguished from the previous generations by the fact that they rely on interactive communication between man and machine:

audio pointer, sound film, phone vision
on-line computer aids to learning and scholarship
instructional computerized games and simulations
computerized programmed instruction
  (a) by network from large computer
  (b) by minicomputer
video tape or disc recorders
video language laboratories, stationary and portable
  computers presenting visual words and numbers,
  moving and still pictures, and audio language
TV information storage
holographic information storage
instructional interactive TV
  (a) broadcast
  (b) cable
  (c) satellite
  (d) dial access

A different taxonomy of instructional technologies has been proposed by Bretz.[4] Slightly modified this schema includes three hierarchial levels of technological systems:

(a) Recordings/storage/reproduction (prostheses for the memory subsystem of the educational system).

(b) Telecommunications systems (prostheses for the channel and net subsystem of the educational system).

(c) Learning aid systems (prostheses for the associator subsystem of the educational system).

Tables 3, 4, and 5 classify the range of hardware according to this taxonomy and Table 6 classifies the software.

Obviously many alternate taxonomies of instructional media can be conceived, but the above two are sufficient to give an organized view. An additional essential point must be emphasized: the educational function of the medium must be analyzed primarily in terms of what it contributes to the individual student's learning environment. Engineering considerations

(Text Continued on Page 115)

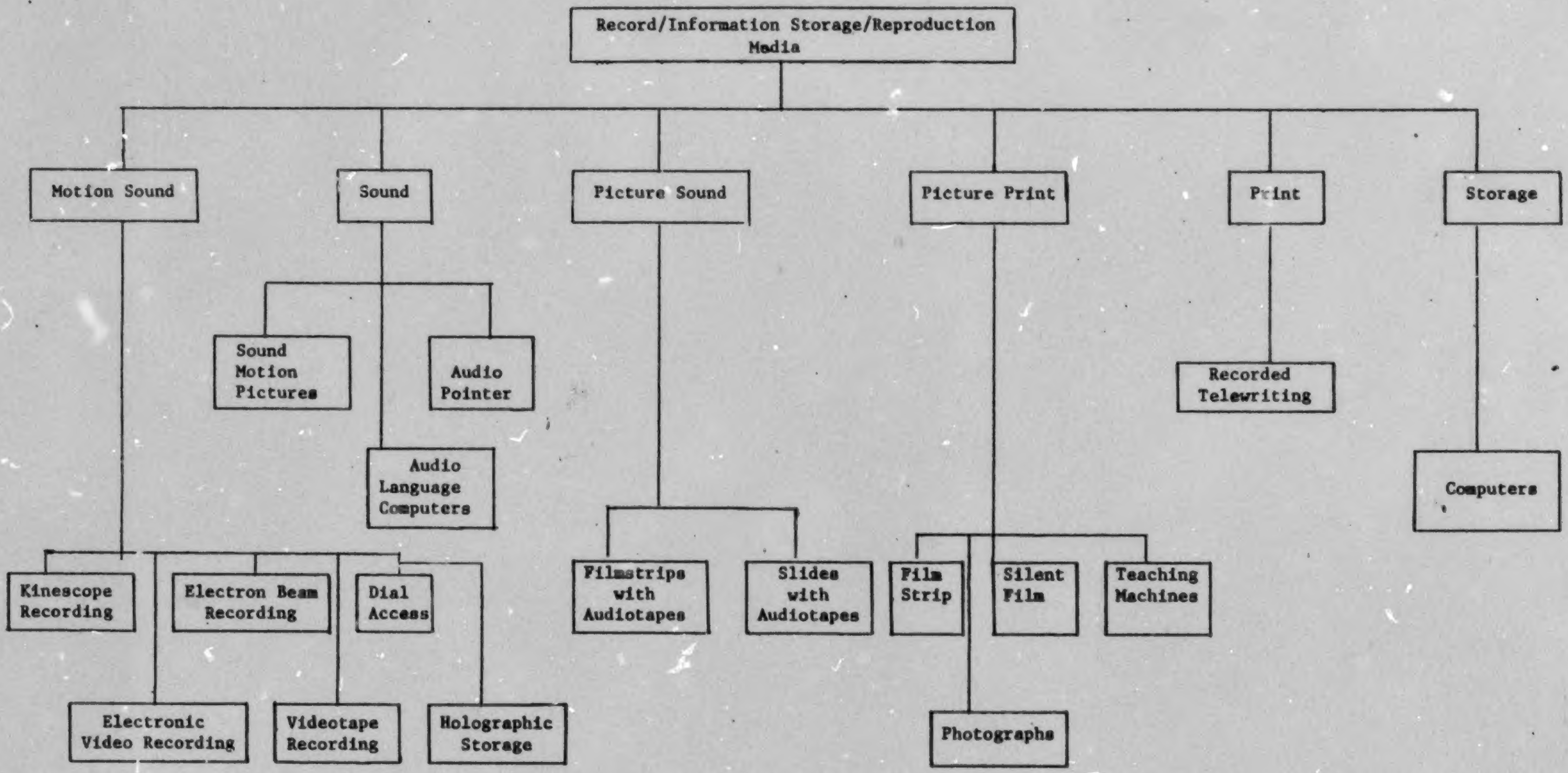
Record/Information Storage/Reproduction Media
Motion Sound
Sound
Picture Sound
Picture Print
Print
Storage
Sound Motion Pictures
Audio Pointer
Audio Language Computers
Recorded Telewriting
Computers
Kinescope Recording
Electron Beam Recording
Dial Access
Electronic Video Recording
Videotape Recording
Holographic Storage
Filmstrips with Audiotapes
Slides with Audiotapes
Film Strip
Silent Film
Teaching Machines
Photographs

Table 3. Record/Storage Information/Reproduction Hardware

(Prostheses for the memory subsystem of the educational system)

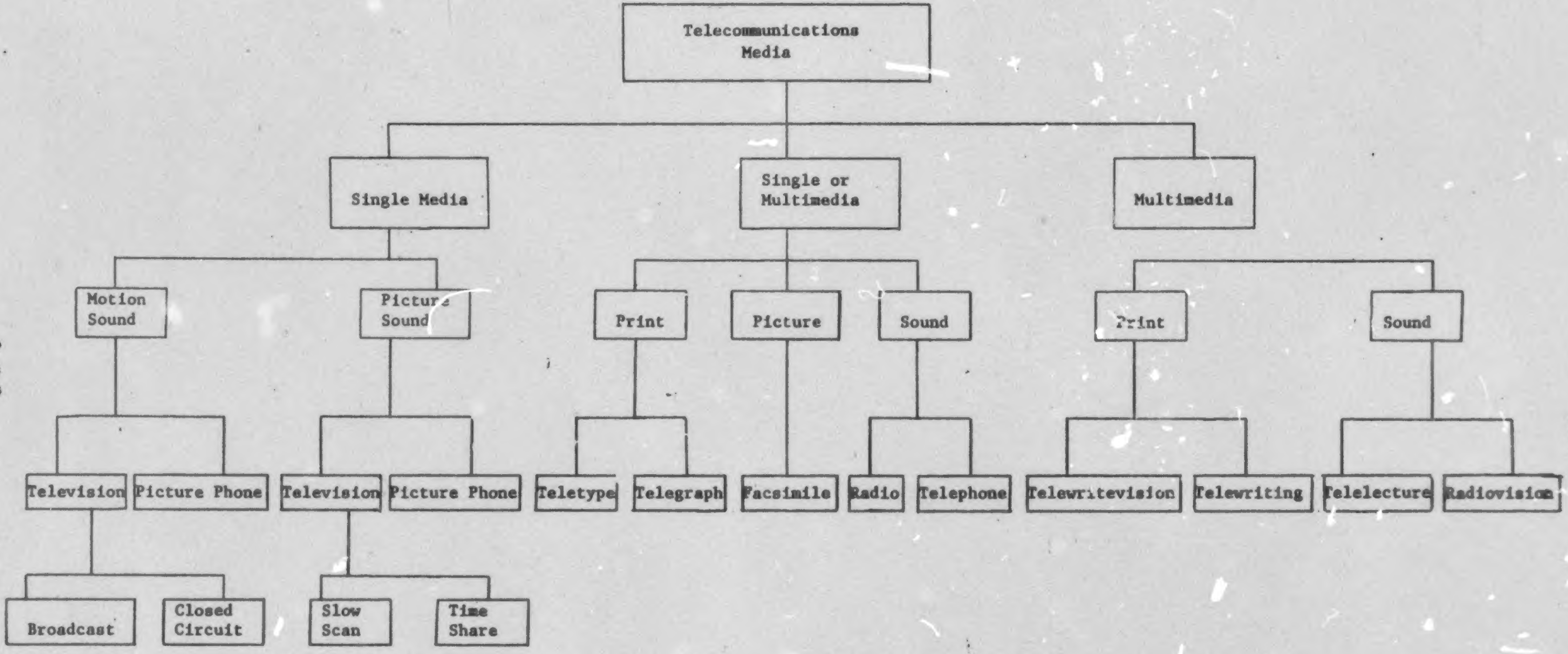
Telecommunications Media
Single Media
Single or Multimedia
Multimedia
Motion Sound
Picture Sound
Print
Picture
Sound
Print
Sound
Television
Picture Phone
Television
Picture Phone
Teletype
Telegraph
Facsimile
Radio
Telephone
Telewritevision
Telewriting
Telelecture
Radiovision
Broadcast
Closed Circuit
Slow Scan
Time Share

Table 4. Telecommunication Hardware

(Prostheses for the channel and net subsystem of the educational system)

COMMUNICATIONS AIDS SYSTEMS

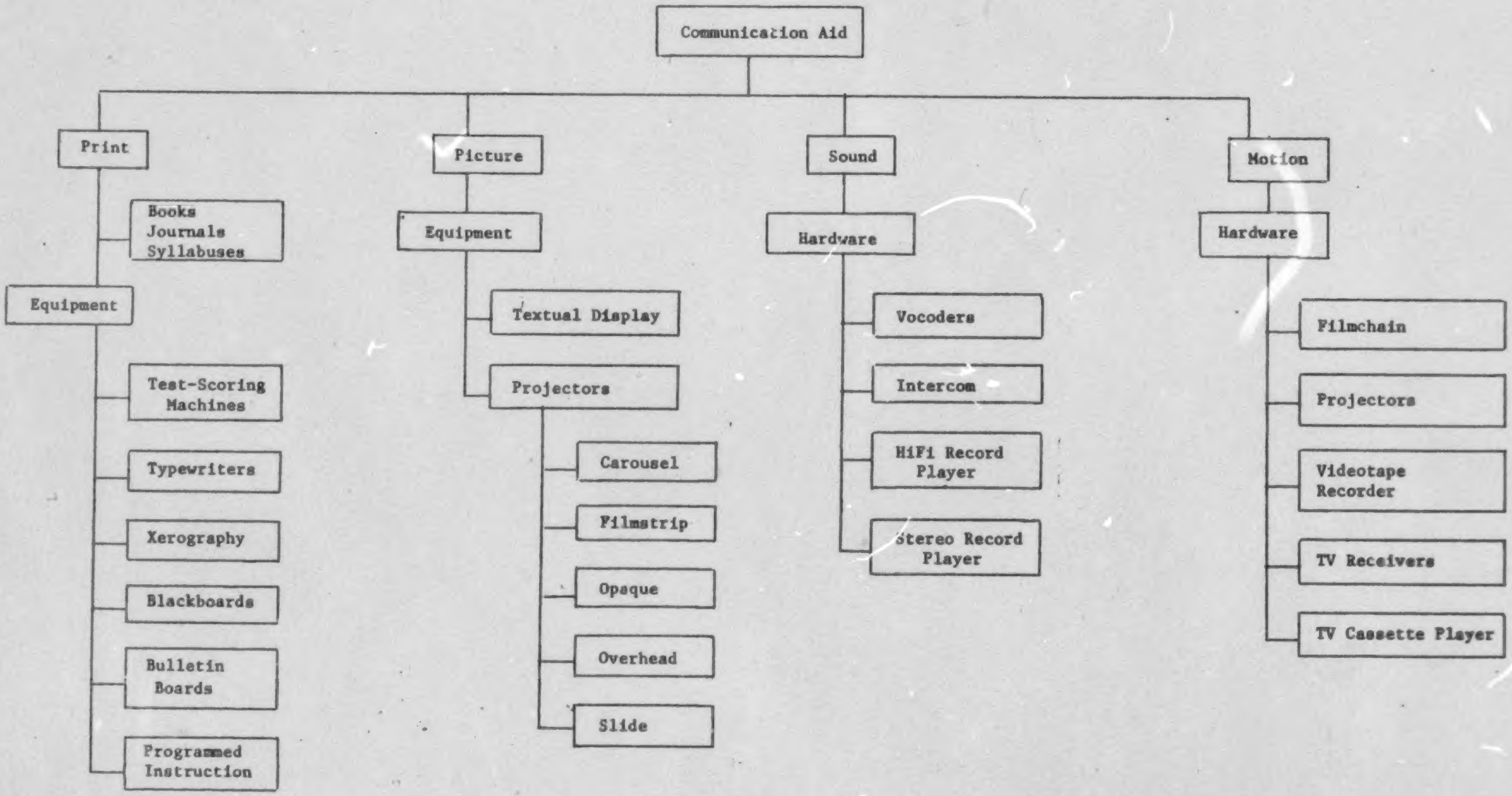
Communication Aid
Print
Books
Journals
Syllabuses
Equipment
Test-Scoring Machines
Typewriters
Xerography
Blackboards
Bulletin Boards
Programmed Instruction
Picture
Equipment
Textual Display
Projectors
Carousel
Filmstrip
Opaque
Overhead
Slide
Sound
Hardware
Vocoders
Intercom
HiFi Record Player
Stereo Record Player
Motion
Hardware
Filmchain
Projectors
Videotape Recorder
TV Receivers
TV Cassette Player

Table 5. Learning Aid Hardware

(Prostheses for the associator subsystem of the educational system)

Software

- Graphics
  - charts
  - diagrams
  - graphs
  - maps
  - stage scenery sets
  - exhibits
- Sound
  - words
  - speech
  - music
  - audio tape programs
- Still Picture
  - symbols
  - illustrations
  - drawings
  - cartoons
  - slides
  - exhibits
- Picture/Sound
  - sound filmstrip programs
  - talking books
  - sound pages
  - phonovid disc programs
- Print or Recorded Symbols
  - lettering
  - written papers
  - documents
  - books
  - workbooks
  - tests
  - programmed textbooks
  - other printed educational materials
  - journals and magazines
  - newspapers
  - computer print-outs
  - writings in Braille
  - punched paper tapes
- Motion
  - sign language
  - finger spelling
  - silent motion picture programs
- Still Picture Print
  - filmstrips
  - microfiche
  - microfilm
- Motion/Sound
  - lectures
  - discussions
  - demonstrations
  - dramatizations
  - field trips
  - video tape programs
  - sound motion picture programs
  - videodisc programs

Table 6. Software

are important but secondary. Another way to put this is that it is the characteristics of the information processing which determines its impact on learning, not the marker that conveys it, the channel that carries it, or the artifactual memory that stores it (see pages 11 to 14). In addition it is useful to distinguish the pluralistic media from the simple ones. TV, motion pictures, videotape and video disc are pluralistic since they carry images of many types and sound of many varieties. Also it is important to recognize that more than printed and computerized programmed instruction and teaching machines can be programmed. So can radio and television. Mass media like multichannel and radio and special effects television, when integrated with new methods for pacing programs for averages of learners, or with feedback from the student, can take advantage of book-machine-computer programming techniques. Clearly when this is done, the number of students using such improved programs can be multiplied manyfold.

Table 7 lists most of the instructional media available today, and states strengths, weaknesses, and costs of each.

The terms which describe the media in this table make clear what they are, with perhaps a few exceptions. Telewriting is remote control of a stylus for writing over an electronic narrow-band channel like a telephone line, audio channel, or alternating current power line. This writing can be displayed to a class by a projector, as it is being done. An audio signal accompanies it, and can be two-way. Telewritevision in addition uses the same projector and screen to show visual materials provided locally.

Table 7

| Instructional Medium | Can user carry it around? | Can user use it individually at school or college? | Can user use it individually at home? | Can user determine when it is to be used? | Can user control rate of information flow & repeat if not understood? | Can user interact actively with input? | Is individualized "branching" possible? | Senses used | Are signals sent on electronic network? | Costs (in dollars per user hour) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. Tutorial sessions or small group discussions | No | No | No | No | Sometimes | Yes | Rarely | Vision & audition | No | 0.50-15 |
| 2. Class lectures | No | No | No | No | No | No | No | Vision & audition | No | 0.15-3 |
| 3. Lettering, writing on blackboard, charts, diagrams, graphs, maps | Often | Yes | Yes | Sometimes | Sometimes | Yes | No | Vision | No | 0.01-0.05 |
| 4. Stage scenery sets | No | No | No | No | No | No | No | Vision | No | 0.01-1 |
| 5. Written papers, documents, books, workbooks, tests, programmed textbooks, other printed educational materials, newspapers, journals, computer print-outs, Braille writings, punched paper tape | Yes | Yes | Yes | Yes | Yes | Sometimes | Only with programmed textbooks | Vision | No | 0.01-0.05 |
| 6. Demonstrations | Sometimes | Sometimes | Sometimes | Sometimes | Sometimes | Sometimes | No | Vision & audition | No | 0.05-1 |
| 7. Dramatizations | No | No | No | No | No | No | No | Vision & audition | No | 0.05-5 |
| 8. Exhibits | No | Sometimes | No | Yes | Yes | Sometimes | Rarely | Vision & audition | No | 0.05-1 |
| 9. Field trips | No | No | No | No | Sometimes | Sometimes | No | Vision & audition | No | 0.25-5 |
| 10. Photographs, filmstrips | Yes | Yes | Yes | Yes | Yes | No | No | Vision | No | 0.01-0.50 |
| 11. Teaching machines | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Vision & rarely audition | No | 0.05-0.15 |
| 12. Silent motion pictures | Yes | Sometimes | Rarely | Rarely | No | No | No | Vision | No | 0.25-3 |
| 13. Filmstrips or slides with audio tapes | Yes | Yes | Yes | Sometimes | Yes | No | No | Vision & audition | No | 0.05-1 |

Table 7
(cont.)

| Instructional Medium | Can user carry it around? | Can user use it individually at school or college? | Can user use it individually at home? | Can user determine when it is to be used? | Can user control rate of information flow & repeat if not understood? | Can user interact actively with input? | Is individualized "branching" possible? | Senses used | Are signals sent on electronic network? | Costs (in dollars per user hour) |
|---|---|---|---|---|---|---|---|---|---|---|
| 14. Sound motion pictures | Yes | Sometimes | Rarely | Rarely | No | No | No | Vision & audition | No | 0.25-5 |
| 15. Telephone | No | Yes | Yes | Yes | Yes | Yes | Yes | Audition | Yes | 0.02-1 |
| 16. Broadcast live instructional radio | Yes | Yes | Yes | No | No | Yes, if feedback | No | Audition | Yes | 0.01-0.50 |
| 17. Telewriting, telewritevision | No | No | No | Rarely | No | No | No | Vision | Yes, except only writing for telewritervision | 0.02-1 |
| 18. Audio tapes, cassettes, cartridges, records | Yes | Yes | Yes | Yes | Yes | No | No | Audition | Yes | 0.02-0.25 |
| 19. Dial-access audio tapes | No | Yes | Rarely | Yes | In some systems | Rarely | No | Audition | Yes | 0.01-2 |
| 20. Teletype, telegraph | No | Yes | No | Yes | Yes | Yes | Yes | Vision | Yes | 0.02-1 |
| 21. Closed-circuit audio lectures | No | Yes | No | No | No | Yes, if feedback | No | Audition | Yes | 0.02-2 |
| 22. Radiovision | No | No | No | No | No | Yes, if feedback | No | Vision & audition | Only the audio signal | 0.02-1 |
| 23. Slow-scan TV | No | No | No | No | No | Yes, if feedback | No | Vision | Yes | 0.02-1 |
| 24. Broadcast live instructional TV | No | Yes | Yes | No | No | Yes, if feedback | No | Vision & audition | Yes | 0.02-1 |
| 25. Closed-circuit live instructional TV | No | Yes | No | No | No | Yes, if feedback | No | Vision & audition | Yes | 0.03-3 |
| 26. Broadcast tape-recorded instructional TV | No | Yes | Yes | No | No* | No | No | Vision & audition | Yes | 0.01-1 |
| 27. Closed-circuit tape-recorded instructional TV | No | Yes | No | No | No* | No | No | Vision & audition | Yes | 0.03-2 |

Table 7
(cont.)

| Instructional Medium | Can user carry it around? | Can user use it individually at school or college? | Can user use it individually at home? | Can user determine when it is to be used? | Can user control rate of information flow & repeat if not understood? | Can user interact actively with input? | Is individualized "branching" possible? | Senses used | Are signals sent on electronic network? | Costs (in dollars per user hour) |
|---|---|---|---|---|---|---|---|---|---|---|
| 28. Facsimile transmission | Yes | Yes | Possibly | Yes, during hours sender is able to transmit to user | No | No | No | Vision | Yes | 2-15 |
| 29. Audio pointer | Yes | Yes | Yes | Yes | Yes | No | No | Vision & audition | No | 0.05-0.25 |
| 30. Phone vision | No | Yes | Yes | Yes | Yes | Yes | Yes | Vision & audition | Yes | 0.50-2 |
| 31. On-line computer aids to learning & scholarship | No | Yes | Rarely | Yes, unless too many other terminals are in use | Yes | Yes | Yes | Vision | Yes | 5-100 |
| 32. Instructional computerized games and simulations | No | Yes | Rarely | Sometimes | Yes | Yes | Yes | Vision | Yes | 2-25 |
| 33. Computerized programmed instruction | No | Yes | Rarely | Yes, unless too many other terminals are in use | Yes | Yes | Yes | Vision & rarely audition | Yes | 2-25 |
| 34. Videotape or disc recorders | Possibly | Yes | Possibly | Yes | Yes | No | No | Vision & audition | No | 0.15-2 |
| 35. Video language laboratories | No | Yes | No | Yes | Yes | Yes | No | Vision & audition | Yes | 0.25-2 |
| 36. Computers which output visual words and numbers, moving and still pictures, and audio language | No | Yes | No | Yes | Yes | Yes | Yes | Vision & audition | Yes | 5-100 |

Table 7
(cont.)

| Instructional Medium | Can user carry it around? | Can user use it individually at school or college? | Can user use it individually at home? | Can user determine when it is to be used? | Can user control rate of information flow & repeat if not understood? | Can user interact actively with input? | Is individualized "branching" possible? | Senses used | Are signals sent on electronic network? | Costs (in dollars per user hour) |
|---|---|---|---|---|---|---|---|---|---|---|
| 37. TV information storage | Yes | Yes | No | Yes | Yes | Yes | Yes | Vision & audition | Yes | 2-25 |
| 38. Holographic information storage | No | Yes | Possibly | Yes | Yes | Yes | Yes | Vision | Yes | 2-25 |
| 39. Instructional interactive TV, time-shared TV | No | Yes | Yes | Yes | Yes | Yes | Yes | Vision & audition | Yes | 0.25-5 |
| 40. Dial-access instructional TV | No | Yes | No | Yes, unless too many other terminals are in use | Sometimes | Rarely | No | Vision & audition | Yes | 0.25-5 |

Table 7. Characteristics and Costs of Various Instructional Media

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* See pages 162 and 163.

Telelecture is a lecture by telephone coordinated with visual materials displayed locally. Radiovision is the same thing with sound by radio instead of telephone. Slow-scan television is transmission of TV still pictures over a medium of narrow-band width like radio or telephone channels. Only one picture can be transmitted every few seconds. Audio pointer is little known. It is a medium based on an audio cassette which has a sound track and a second signal track that controls the movement of a spot of light over a translucent sheet on which pictures or designs can appear. Thus, the light can point to various parts of the display in coordination with the sound track. "On-line computer aids to learning and scholarship" refers to such technologies as Project MAC at MIT. An individual user of Project MAC can get access, by a remote terminal on-line to a large time-sharing computer, to a wide range of programs that can help him solve mathematical, scientific, and engineering problems, routines for displaying the results of such problem solutions, tests of students' content knowledge in different fields, psychological and behavioral tests, and references or abstracts of articles relevant to many academic tasks. All of these materials are almost instantaneously available for the user to interact with in a "conversational" mode that requires little or no understanding of mathematics or computer programming. "Instructional computerized games" refers to various sorts of war games, business management games, and similar exercises in which players representing competing interests interact with a computer and so learn how to deal with competitors or opponents like those in real life. "Simulations" are models of real systems programmed in computers which enable a person interacting with them to learn how such systems act. TV information storage is use of TV tape to store symbols and still and moving pictures. Holographic information storage uses the relatively newly developed hologram, a three-dimensional picture stored on a two-dimensional plane surface, to store a large amount of information in a relatively small area. Also highly advanced, largely in the future, are interactive and time-shared TV, which are among the novel forms of TV which Licklider has called "televistas."[5] These include specialized transmissions to individual users which he calls "narrowcasting" and techniques which permit the receiver to respond actively to television transmissions as well as employ television channels to use a variety of other instructional media. A number of other media and combinations might be listed, but Table 7 is sufficient to give a panoramic view of the alternative media available to educational systems today.

Many persons concerned with the field of education are scarcely aware that there are as many alternative forms of instructional technology, or at least they have not had direct personal experience with them. One reason for this is that the number of media has risen dramatically because of technological developments in the last decade or two. When the educators were themselves in school or college, some media did not yet exist.

These technologies are fundamentally products of the Second Industrial Revolution--the information-processing revolution--which burgeoned about 20 years ago, although it began in the last century with the telegraph, the telephone, and radio. The First Industrial Revolution flourished around 1800, being characterized by such major developments as the invention of the cotton gin, the steamboat, the steam engine, the electric motor, electric lights, the automobile, and the airplane. And it continues vigorously up until today with the developments in missiles, space travel, and atomic energy. Of course, the earliest such inventions occurred far back in history or prehistory, with the domestication of animals and the construction of dams and wheeled vehicles. This first revolution produced artifacts which operate as prostheses to living systems at various levels to carry out matter-energy subsystem processes. These machines can perform these processes faster or more efficiently or with less cost in human energy (although there may be more over-all expenditure of energy) than human beings can themselves.

Now, with the appearance of the computer, with its rapid improvement in capacity and sophistication, with the perfection of new communications technologies, and with the general increase in efficiency, speed, and compactness of the machinery which processes information, the second revolution is well underway. We see in operation prostheses to aid living systems in the activities of the entire range of their information-processing subsystems. These include input transducers--microphones, sonar, radar--which can receive signals that cannot be detected by any unaided living systems; channels and nets which can transmit information at the speed of light and for great distances; computer aids to learning, to memory, to management decision making; and output transducers like slide projectors, public address systems, radio, and television that can transmit messages rapidly, accurately, over greater distances, and to more people than can any living system.

Any educational system that is conscientiously intent upon raising the quality and lowering the costs of its functions would do well to undertake cost-benefit or cost-effectiveness analyses, studying the trade-offs among these alternative technologies, attempting to determine which will provide the greatest excellence under what circumstances, and which will be cheapest.

Any such analysis will reveal that it is not enough simply to add these technologies to procedures already in use. This will increase costs and will, in all probability, not permit optimal use of the new methods. Rather both structure and process of the system must usually be altered, often quite fundamentally. People must change their ways. Budgets must be adjusted.

A brief inspection of Table 7 indicates a number of things about the various instructional media available today. First of all, it is apparent that there are a good many of them, the number varying according to how they are classified, but one does not need to extend one's self to list 40, as in this table. The first two listed involve only living systems and do not require any artifacts as prostheses. For this reason they are separated by a double line from the other media below them. The first two are the traditional media which have been used for generations, and the choice between them has classically faced educators--whether to use large class lectures or small discussion groups (including individual tutorial sessions).

If one looks across the columns on the chart, it is apparent that the media differ widely in their characteristics and costs. This fact makes evaluation of their cost-effectiveness in different learning situations and with different sorts of students essential.

A large body of research on learning, in general psychology and educational psychology, gives us some idea of what constitutes an optimal learning environment. One cannot say that this knowledge is yet definitive, and it clearly differs from individual to individual, since each one's genetic characteristics and past experiences result in differences in behavior, personality, and temperament. Nevertheless, we can say with some confidence that aids to learning are most useful if the student can (a) carry them around, for then they are available whenever needed; (b) use them individually rather than having to coordinate his activities with class groups or other students; (c) use the aids anywhere, both at school or college and at home; (d) determine in terms of his own needs and schedule when to use the materials; (e) control the rate of flow of information inputs and outputs in the learning process, and repeat inputs at will if they are not understood; (f) interact actively with the aids, since active learning is generally recognized as being better than passive; (g) be able to have outputs from him influence the next input coming to him. This "branching" arrangement assures that, if he knows one fact in the progression of the learning process, he is not given special training on it but goes on to the next one and so forth until he comes to a fact which he does not know or a problem which he cannot solve properly, after which he is given special training on that, his time being used for practice only on those facts or problems which he does not understand; (h) receive inputs in more than one sensory modality, since multiple sensory modalities represent multiple channels of input which reinforce each other. Learning aids are more useful if they can be transmitted over electronic networks so that they can reach the student at any place he happens to be, coming rapidly and accurately from any other geographical location. It is also desirable for their costs to be minimal in dollars per user hour, as well as in the time they consume of the student or instructor involved.

None of the media listed in Table 7 is optimal in all these ways. Some are better than others, and some are more appropriate than others for certain situations or when certain amounts of funds are available to the educational system. These differences among the media make careful analysis of the trade-offs among them mandatory.

For instance, the first column shows that less than half of the media listed are truly portable. None of the other media, in their present form, are truly portable so far as the average student is concerned. Technical advances may make some of them much more portable in the near future.

The second column in Table 7 shows that students working alone at school or college can profit from most of the media, the exceptions being the class lectures, tutorial sessions or small group discussions, stage scenery sets, dramatizations, field trips, telewriting, telewritevision, radiovision, slow scan TV, the audio pointer, and closed-circuit lectures on public address systems. Students can use slightly more than half of the media at home. Technical improvements in a number of others could render them readily available for home study.

A major constraint upon several of the media, as the fourth column indicates, is that the student must fit his schedule and convenience to that of a group, which limits the most effective use of his time.

This is true of class lectures; small group discussions; all broadcast and closed-circuit programs; stage scenery sets; dramatizations; and field trips. Probably any form of radio or television which requires large numbers of students to use the medium simultaneously regiments them undesirably. This may be a major reason why instructional radio and television have not been more effective. The custom of herding students into classes at certain hours is so ingrained in the world's educational systems that it is hard to break. Many teachers forget or actually do not believe that usually the optimal learning situation is probably one in which each student sets his own schedule and studies independently at his own pace.

If the individual student can control the rate of information flow during learning, he is not likely to fall behind in understanding the content or be bored waiting for new concepts to come to him. Many of the media, as the fifth column of Table 7 shows, give the student this sort of control, but some do not. Students rarely exert any influence on the rate of progress of class lectures, which is one of the primary reasons why lectures are far from perfect learning situations. More often students can exert such influence in small group discussions, and in tutorial sessions they usually do. If a teaching group is very large, however, some of the students are likely to be too passive or too shy to request a change when the rate of information flow is not optimal for them. Tradition dictates that the experienced, senior person--the teacher--determines information flow rates. Broadcast and closed-circuit lectures on any media, live or recorded, have these shortcomings as well. Exceptions are dial-access TV systems or TV or audio tape players which permit a student to stop a lecture at will, reverse it, and listen to it again. Many other media are self-pacing.

Most of the media do not permit the user to interact actively with the input. This is one of the great advantages of the small discussion group and a major point in favor of computerized programmed instruction and of on-line computer aids to learning and scholarship. Under some circumstances, dial-access audio tape recordings make such interaction possible. For instance, a language laboratory tape may present a student with a word or sentence in a foreign language and give him an opportunity to repeat the word or sentence, which is then tape-recorded and later listened to by a teacher who corrects his pronunciation. Similar procedures are possible with dial-access instructional television. Under some circumstances a student or professor can interact with automated data banks for information storage and with some of the standard audio-visual aids. Feedback circuits used with media which employ communication over distance for educational purposes can enable students to interact with a live teacher. This is possible with two-way telegraph, telephone, radio, TV, telewriting, slow scan TV, or combinations of such media, *e.g.*, TV from teacher to student with radio or telephone responses. Also telegraph, telephone, radio, or TV responses from students can be used with telewritevision, telelecture, and radiovision. Such feedback circuits can also enable a student to interact at a distance with computerized programmed instructional materials which can be transmitted to him by audio circuits, TV, or slow scan TV.

A major potential of programmed instruction and on-line use of computers is individualized instruction. With them a student does not need to rehearse repeatedly material he already knows. He employs the time saved from avoiding unnecessary repetition, instead, in further practice on what he does not know. This can enable the student to save time, or at least allocate it better, in the learning process. Lectures and broadcasts do not usually have such a potential, although on occasion very small discussion groups or individual tutorial sessions do. The programming technique whereby each student is given practice only on what he does not know is called "branching." Such branching is less personalized, flexible, and sophisticated in the best printed programmed instruction than in the best computerized programmed instruction and on-line computer aids to learning and scholarship. Various automated storage and retrieval technologies also permit a close tailoring of the process to the needs of the individual user.

As the eighth column of Table 7 indicates, the face-to-face human situation in class lectures, tutorial sessions, and small group discussions has the distinct advantage of permitting use of both vision and audition, as well as some of the other sensory modalities on occasion. Books, journals, printed programmed instruction, closed-circuit lectures on audio systems, educational radio, fascimile transmission of documents by electronic circuits, and certain other media do not use both sensory modalities. Other media do use both, such as sound moving pictures, and in more limited ways, telelecture, radiovision, and audio pointer. So do the different forms of television. This is one reason why television is probably superior in conveying a sense of intimate and direct human relationships to books, computer terminals, or radio.

If educational materials can be transmitted over electronic channels and networks, they can, in principle, be initiated at any geographical point and be used at any other point. This facilitates diffusion of knowledge and makes possible democracy of access to educational information. The face-to-face relationships of tutorial sessions, small group discussions, and class lectures do not have this potential, nor do many other media like documents, books, journals, printed programmed instruction, or the standard audiovisual aids. As the next-to-last column of Table 7 shows, most of the electronic media do. In the last few years educators have been presented with a challenge they never faced before: How can one best choose among the new network media most profitably and creatively use them for education?

Now we come to the question of costs. The last column of Table 7 lists only roughly estimated dollar costs in various sorts of matter-energy and information, although, of course, costs in student, teacher, administrative, and other staff time are also important. The dollar estimates include both operating funds and an appropriate portion of capital construction funds. For each of the media a wide range in costs is shown. This is because costs differ from one situation to another and because it is difficult to make even rough cost estimates with our present understanding of the media. Many variables influence the dollar cost per user hour of these different media. Among these are: the number of students using the medium at a given location and a given time; the ratio between the number of students and the number of instructors; the amount of hardware employed in the particular system under study; the number of hours the hardware is used on the average by each student; the original costs of the hardware (which over the years have been rapidly decreasing); whether the hardware is bought in large quantities; and whether the software needs to be written for the local system or has already been prepared for another system.

A few general observations about costs can be made: (*a*) Large class lectures are less expensive than small group discussions. (*b*) Even though none of the electronic media has all the advantages of direct human contact, some of them appear to be, at least potentially, as cheap or cheaper than traditional methods of teaching by direct human contact. (*c*) Books, journals, and other printed materials are, in general, cheaper than most of the electronic technologies, though this is not necessarily true when the latter are used with large numbers of students. (*d*) Electronic technologies involving both vision and audition are more expensive than those that involve audition alone. (*e*) Those media which involve on-line access to computers are, in general, significantly more expensive than the other media, at least at their present stage of development.

## 5. Selecting Priorities for Research on Instructional Technologies in Less Developed Countries

*5.1 Introduction*. The use of instructional technologies in less-developed countries is proliferating. In *The New Media: Memo to Educational Planners* Schramm, Coombs, Kahnert, and Lyle list nine developing countries that are using television and five using radio for various educational activities.[6] Since this report was published in 1967, two satellite projects have entered the planning stages in Brazil and India; television has been adopted as the basic ingredient of major educational reforms in El Salvador, Colombia, the Ivory Coast, and probably Tunisia; educational radio has demonstrated success in Kenya and Nigeria, both with and without correspondence materials; and educational television has started in Brazil, Ethiopia, and Zaire.[7] Also a major investigation of the potential for educational broadcasting in Indonesia has been proposed by UNESCO and an inexpensive local television system is being tried in the Philippines.[8]

To some extent the experiences of past and current projects using communications technologies for solving educational problems in developing countries have been digested and analyzed. However, no systematic attempt has been made to set in priority order the most important areas for future research on the use of instructional technologies in less developed countries.

There are at least four ways to look for research priorities in a field such as this.

(a) Review the possible solutions to the problem and look for a problem that goes with what seems to be a good solution. This approach has been fairly common in the field of communications technologies applied to education. A product is developed to meet a particular need, then problems in other fields are identified to which it can also be applied. Because the market for communications technology is continually being manipulated by suppliers in established countries who often pay inadequate attention to the needs of the less developed countries, this kind of approach is particularly common.

(b) Move from the problems to potential solutions. Different problem areas can be defined and put in priority order according to their urgency and the expected impact of an acceptable solution to them. William Platt's summary of research needs in educational planning, Research for Educational Planning: Notes on Emergent Needs, is an example of this kind of approach.[9] Philips Coombs's book The World Educational Crisis: A Systems Analysis is another example of a cataloguing of the problems.[10] It proceeds from an assessment of needs to alternative solutions. The weakness of this approach is that often the people who know about the problems are not knowledgeable about the range of solutions and are incapable of communicating with those who do. It is extremely difficult, especially when technology is involved, to translate problems into statements which can then be examined for their susceptibility to solution. For example, a problem statement such as "low performance on cognitive tests" does not contain information useful in selecting one technology as opposed to another.

(c) Catalogue and evaluate different characteristics of the problem and determine how a given solution copes with each of them. Allen has done this. He outlined factors that determine the effective use of instructional technology.[11] He discussed media-related factors such as types of instructional materials, form and organization of the material, student response patterns, attributes of the content, attributes of the learners, and instructional uses to which the media are put.

(d) Develop an integrative conceptual system to describe the field. Then outline the major problems in terms of this scheme, setting up a map of possible research projects. Then determine the priority order for carrying out these investigations in terms of their a priori probability of improving instructional cost-effectiveness. Finally determine the most appropriate one of the less developed countries and the best situation in that nation to do the study. The approach which we use in this study borrows from all the above approaches but follows the last most closely.

5.2 Method of procedure. A seven-step approach to identifying research priorities in instructional technologies for application to educational problems in less developed countries is employed in our study. We define research broadly to include experiments, field studies, controlled observations, hardware and software development activities, and any other projects whose purpose is to provide information useful in improving the cost-effectiveness of education in less developed countries. Such a question might involve changing the organization or processes currently in effect in an educational system, or determining the feasibility of using one or more instructional technologies in it, to improve its cost-effectiveness.

Determining research priorities necessitates (a) forecasting future problems and their relative importance; (b) evaluating the potential applicability of solutions to those problems; (c) estimating the feasibility of the problem-solution match in terms both of the political and social acceptability of the solution and of its economic feasibility.

The seven basic steps of our approach are:

1. Establish interest in instructional technologies
2. Identify educational problems, diagnosing existing organizational pathologies

3. Formulate research questions to answer in evaluating alternative human and/or technological solutions to the problems
4. Specify research designs
5. Arrange projects in priority order
6. Carry out research
7. Evaluate research findings for operational implications

### 5.3 Procedural details

| Steps | Comments and/or alternatives |
|---|---|
| 1. Establish interest in instructional technologies. Discuss with educational decision makers the likelihood of solving some education problems by means of changes in structure or processes of the human educational system or the use of instructional technologies; assess their perceptions of the feasibility of introducing communications technologies. | 1. Interest in using instructional technologies in an educational system arises from a desire to increase the quality or quantity of instructional services available to the society or to cut their costs. It should be recognized from the beginning, however, that use of instructional technologies will require adaptations in the educational system if they are to be employed effectively. It is wise to prepare for educational reform as well as educational expansion when considering educational technology. It is desirable to maintain both optimism about what technology can potentially do and hardnosed skepticism about what it costs and can currently do. Concern for these issues by the Agency for International Development was formally established by the Foreign Assistance Act of 1970, under Section 220. AID has established an office under the direction of Dr. Clifford H. Block, in the Technical Assistance Bureau to implement the implications of the legislation. AID's interest is reinforced by the growing number of requests for technical guidance and financial assistance in communications technologies from its clientele in the developing countries. Nevertheless, many less developed countries and many of the AID desk officers for such countries are as yet unconvinced about the potential of instructional technologies. |

### Steps

2. Identify educational problems, diagnosing existing organizational pathologies. This can be done by means of a literature search, interviews with educators about their current activities, a survey of those who benefit from education (parents, students, employers, etc.), or analyses of management information about the educational system.

### Comments and/or alternatives

2. Statements of problems will be expressed in a variety of ways, sometimes in reference to performance standards that are not being attained, sometimes in terms of the scarcity of resources available to undertake the process of education, and sometimes in terms of vagaries and inefficiencies of the society that uses education. Often a statement of a problem is at the same time a statement of the causes of the problem. It is important to obtain and distinguish these two sorts of information.

Because of the perspective of this report this task was almost immediately perceived as finding a way to organize information about problems. It could not be hoped within the confines of this work to arrive at a new understanding of the educational problems being faced by developing countries. We could not even hope to be able to prioritize them in a way that would reflect anything other than our own opinions.

The educational literature was also examined by us in order to identify important problems. Coombs' schema of the major components of an educational system came closest to providing this. According to Coombs, all educational problems seem to fall into four areas. These four areas include the two output categories of learner performance and the integration of education with society and the two process problems of learner-input interaction and educational management (all interactions in educational systems that do not include the learner.)[12] Ultimately, the problems classified according to process and output depend on the quantity and quality of the inputs to the educational system.

Steps

Comments and/or alternatives (2 cont.)

All four of these areas cover a multitude of problems. First, the conventionally defined academic learning performance of most learners in developing countries is low. Performance on cognitive tests is often low; illiteracy levels are usually high, even where substantial literacy programs have been tried; and training in family planning, hygiene, agriculture, and technical trades has not been overly successful. Second, those learners who finish their education have difficulty integrating themselves into the society. They often have unrealistic expectations of development, elitist attitudes toward society, and levels of training which are less than satisfactory to fit them for jobs. Also, the educational system as a whole has not been adequately integrated into society. Present educational systems tend to

- resist the innovation needed for development
- enhance the urban-rural dichotomy of most developing countries
- provide unequal access to education
- maintain a gap between what is taught in school and what the society considers important; and
- perpetuate the mismatch between manpower needs and the demand for education

The two process problems--learner-input interaction and educational management--are similarly complicated.

| Steps | Comments and/or alternatives (2 cont.) |
|---|---|
| | First, few definite statements can be made about the process by which a person learns. This is an especially pressing problem in the application of media to education, one which is made worse in less developed countries by the diversity of cultural, social, and psychological conditions that exist. Also, in such countries the management of education needs improvement. There is often no coherent relationship between decision-making, planning, and research. Many educational managers (supervisors, education officers, etc.) lack knowledge of basic management principles and there is a shortage of well prepared teachers, good educational administrators, and suitable facilities at the school or local level. |
| 3. Formulate research questions to answer in evaluating alternative human and/or technological solutions to the problems. The questions to be answered should be as specific as possible and be practically relevant to the educational problems in the less developed country or countries in which the investigation is conducted. In some cases the question may be whether a specific procedure is feasible. In others it may be whether it is more cost-effective than an alternative procedure. Some alternatives may involve only changes in structure or processes of the human educational system, with no hardware or software involved ; others may concern introduction of both hardware and software. | 3. Research questions should be stated, if possible, as hypotheses and in operational form so that, when answered by research, they reduce the uncertainity of educational planning and provide a rational basis for more efficient allocation of resources. |

| Steps | Comments and/or alternatives |
|---|---|
| 4. Specify research designs. Research specifications include a statement of objectives, i.e., what the final product of the research is supposed to be; a statement of relevant research, reviewing the literature related to the question at hand; a section describing the research program which specifies the tasks to be undertaken; a section on staffing and scheduling which estimates the phasing of the tasks, the skills required to undertake the research, and the number of man/months to complete the research. The research specifications should institute a work statement that could be given to an investigator who decides to undertake the effort. Precision of design is important, but many issues inevitably must and should be left to the researcher's discretion. | 4. In most cases the research proposed will be applied research and developmental work. Applied research presumes that basic research has been completed. It builds on basic research. Much basic educational research, however, has not been successfully completed. There is little to build on. Attempting to measure educational effectiveness raises many difficult issues for behavioral scientists. Yet it is of major practical importance that instructional media be compared for educational cost-effectiveness. In Chapters IV and V of this report, 29 research projects of importance to the use of instructional technology in less developed nations are mapped out in order to demonstrate their interrelationships and then their designs are specified in some detail. |
| 5. Arrange projects in priority order. Once research specifications have been developed for each project, their relative priorities must be established on the basis of several considerations. In some cases it is obvious that certain questions have to be answered before other researches can be undertaken. Methods of cost-effectiveness evaluation, for instance, must be developed and tested before they can be relied on. Effectiveness of a procedure must be proved before the way it is employed in a particular system can be considered. Priorities | 5. Educational research involving media is quite expensive. Pilot projects can cost $500,000 and more. Since a really reliable cost-benefit analysis of a research project cannot be made until it is completed, however, decisions about how to allocate research resources must be based on a highly subjective analysis of the opportunity costs of doing or not doing a certain research project as compared to similar costs for alternative studies. The understanding of the project developed in Steps 1 through 4 gives some sense of the benefits not of the research, but of the successful implementation of organizational change or new use of technology should the |

| Steps (5 cont.) | Comments and/or alternatives (5 cont.) |
|---|---|
| can be set by a crude, subjective cost-benefit analysis. The generalizability and applicability of a project must be estimated in determining its potential benefits. The costs in human effort and money of all the research and development required before the findings can be made operational are measures of its costs. By using such rough criteria the projects that should be undertaken first can be selected. | research indicate that this is feasible and/or cost-effective. In addition we include in our analysis some estimates of probable benefits from any technology employed in the project, based on its record of prior performance. We also have some idea of the research costs to arrive at an answer to the question of whether that match is feasible. We do not have any clear information as to the probability that the research findings will be positive in terms of the feasibility and usefulness of the procedures investigated. We also have no information on the practical problems of implementing findings of the research. Nevertheless it is advisable, and indeed necessary if priorities are to be set to attempt such analyses even though the level of confidence that can be placed in the calculations is low. In Chapter IV the 25 projects are grouped into three priority classes, A, B, and C, and within each class a rough rank ordering of priorities is made. These rankings are based on the procedure outlined above. |
| 6. Carry out research: If the staff does not exist with the capability to undertake the research the personnel must be recruited. The specific site for the study must be selected, as well as the educational systems which will be investigated and the controls to be employed. A detailed research plan and a schedule must be agreed upon and rigorously adhered to. Data must be carefully collected and analyzed. | 6. In most of the less developed nations there are few if any scientists capable of independently conducting sophisticated research to evaluate the structure and processes of educational systems and the potential contributions to them of instructional technologies. This means they will in most cases need consultation and perhaps major assistance from persons from other countries who have the necessary background for this relatively new sort of research for which procedures are still far from standarized. |

| Steps | Comments and/or alternatives |
|---|---|
| 7. Evaluate research findings for operational implications: Several possible sorts of practical implications may arise from research findings:<br>(a) The findings are inconclusive and further study is required.<br>or (b) The findings are conclusive and (i) other researches on other components of the system are now required before action is taken to implement new procedures; (ii) no further research should be undertaken because no changes are indicated; or (iii) implementation of the new procedures should began forthwith. | 7. Even though the findings from a study may provide clear and rational evidence that a certain educational procedure should be carried out, many other considerations must be reviewed to see if it is feasible. There may be overriding political reasons why it cannot be implemented. Or it may be socially or culturally unacceptable. Or it may be so costly that the nation cannot afford it. The final decision about implementation must be made by governmental authorities rather than scientists, for only they are in a position to weigh all these considerations. |

## 6. Determining the Practical Feasibility of Implementing a New Educational Procedure

Once the operational implications of the research have been reviewed, the procedures outlined in the above section are concluded. Before the findings can be implemented, however, one other major phase of analysis must be carried out. When a procedure or instructional technology has been selected which appears most likely to make improvements over the traditional uses of scarce educational resources, this choice must be evaluated as to the feasibility of its use in a particular one of the less developed countries. If it appears infeasible it must be dropped from consideration.

This does not mean that the research conducted on it has been fruitless, only that for the particular country under consideration it is at that moment and in that situation impractical.

Feasibility depends on two major considerations: The range of the new procedure's financial cost and its acceptability to the particular country. Let us deal with each of these in turn.

6.1 Costs. Three major categories of monetary and nonmonetary costs deserve consideration: development, implementation, and maintenance costs.

First, the development costs must be estimated. This can be done by analyzing carefully and in detail the state of the art now and comparing it with the state required before it is ready for regular application. Then the time and manpower needed to reach the latter state can be worked out.

Second, once the development costs have been determined, implementation costs must be worked out. These will depend on which instructional hardware, if any, is to be employed, the number of persons likely to use it, the probable hardware/user ratio, the manufacturing and distribution costs, the costs of software production, and the more difficult to calculate, education of persons in the system to accept and use it. Such education is essential if the system is to accept the proposed new procedure. To deal with the social, cultural, and political aspects of educational change takes human effort, money, and time. For instance, the introduction of an educational television system into a less developed country may require creation of a formal, politically and socially acceptable, institution to operate the program. The nucleus for this may already exist in an educational radio system or public television service. If it does not, the implementation costs will include significant institutional development costs.

In the past the most ignored costs have been maintenance costs. Only recently have international funding agencies and donor countries begun to consider adequately the maintenance costs and how they will be funded when deciding on development projects in education. The introduction of language laboratories in less developed countries in the tropics has provided glaring examples of neglect of maintenance costs. The demand for second- and third-language training led to the introduction of tape recorder units that had been designed for cooler climates. Not only was the electricity often inadequate, but humidity and heat caused the equipment to deteriorate rapidly and no maintenance men or spare parts were provided. Extensive periods of downtime for the equipment resulted and consequently administrators became unwilling to invest in more language laboratories.

The major problem is that the less developed country cannot or does not budget operating funds for maintenance costs. The donor agency is often glad to provide as much as 90 or 100 percent of the money required to introduce an innovation in instructional technology. Then they leave it to the country to which it is given to finance all future hardware and software costs. The budgets of the less developed countries are often too low to do this. Long-range financial planning, therefore, is an essential part of the systems approach to the use of instructional technology.

6.2 Acceptability. If an educational technique is to be accepted, it must not be culturally biased against the country where it is to be used. For an innovation to be accepted it may be best to use a medium familiar to a recipient. Thus, if a country has a large radio audience but no TV, innovations in radio may prove to be the most feasible. This assumes that the content presented on the two media are comparably effective. If the TV materials are clearly superior, their impact may be superior.

A minimum of cognitive dissonance in the student should be elicited by the instruction if it is to succeed. "Cognitive dissonance" arises in a person when he is given reason to believe or accept two opposing views simultaneously. Introducing the instructional innovation either as an adjunct to existing acceptable resources or as a completely new, dissociated alternative may present such dissonance. Kenya has followed the first course in introducing educational radio as a supplement to existing textbooks. The latter alternative is more daring, but though risky, it may achieve the most dramatic changes. Acceptance will, however, be jeopardized if technologies are introduced that the users see as contradicting good educational practice, for example, the substitution of teaching machines for teachers. Teachers, students, and parents may all resist this.

In addition to being acceptable to individuals in the societies for which they are designed, novel teaching procedures must also be amendable to institutionalization in their development, diffusion, and maintenance. Esman and his associates have carefully studied this aspect of acceptability. They list the following requirements for institutional acceptability of new technologies:[13]

(a) Leadership is required in technological transfer of any sort because modern technology is complex; leadership must point the way to integrated operations in the institutions accepting the innovations.

(b) Doctrine about the organization's policy must be spelled out as a basis for decentralized as well as centralized decisions, so providing effective system integration and providing for consistency of performance by all units.

(c) The program must be planned in terms of the priorities expected of the outputs of the organization.

(d) Standards of excellence must be established in terms of which the performance of the technological innovation can be evaluated.

(e) Linkages must exist within the educational organization to guarantee integration and consistency of performance, and with other organizations to guarantee relevance and some measure of influence in the society.

and (f) Resources must be adequate to develop and use the technologies introduced.

All this means that the feasibility of a technological innovation depends on the establishment of, or identification with, institutions that have the attributes listed above and that see the diffusion of the proposed innovation as one of their major responsibilities. For example, the introduction of anything so complex as communications satellites for education demands that informed leadership be available to design a program that offers solutions to the multitude of educational problems. Various educators are talking of using these satellites for educational administration, teacher training, classroom instruction, and extracurricular activities. Any program that assigns priorities to these alternatives must also depend on an institution with a doctrine which makes educational goals explicit, standards of excellence related to those goals, and linkages with other organizations in the society interested in education. This institution must also be amply supplied with resources to mount and sustain such an ambitious project.

An established nation which has provided technical assistance has often been chiefly responsible for the decision to adopt a certain instructional medium for education in a less developed country. Its influence resulted not only from its financial support but also from its technical superiority and enthusiasm for educational technology. While the less developed nation often has had great interest in the new technologies its lack of expertise has led it to accept an educational system currently in the spotlight of attention without considering an adequate range of alternatives. A good case in point is the current discussion on the uses of a communication satellite for educational purposes. Almost all work centers on instructional television using the satellite, yet other media can employ satellite transmissions. Consideration is now slowly turning to the possible use of the satellite for radio and for facsimile.[14]

A sign that the weight of decision making may be shifting from supplier-determined selection to a demand-based selection is the Indonesian Central Planning Office's recent refusal to accept UNESCO funds for a series of feasibility and planning studies for educational broadcasting until some consideration is given to other alternatives. The initial draft of the report by the UNESCO mission to Indonesia that outlined studies to be undertaken in order to develop educational broadcasting did not include any suggestion that broadcasting should be compared with any other possible means of educational reform.[15] In less developed nations generally, however, a demand-based system of technology transfer does not exist. More needs to be done to ensure that locally selected, designed, and implemented educational systems using technology are possible.

The last aspect of acceptability with which we must deal concerns the perceived possibilities of diffusion of the technologies throughout the nations once they are developed. On the basis of his studies, Mort has concluded that on the average an educational innovation in the United States takes 25 years before it begins to be accepted.[16] Total acceptance takes about 50 years. This is a disturbing statistic. We must try to minimize the opposition to new technologies. One way to do this is to select those that seem to be most readily acceptable. Besides dealing with the social, cultural, and institutional constraints discussed above we must also select for use technologies which the potential users perceive as desirable.

To be desirable a medium must, first, be perceived as providing more benefits than other alternatives. The most obvious benefits are potential gains in student achievement. But they may also include reduction of preparation time for the teacher, enhancement of the teacher's professional skills, and improvement of the learning environment.

A desirable medium also is characterized by simplicity. The more complex an innovation is the more sophisticated its users must be in order to take full advantage of it. The teacher must be able to understand and operate the technology and the students must find it convenient and rewarding.

For instance, a computer console in a school in the mountains of Bolivia might easily at first produce cultural shock and be beyond the conceptual capabilities of both teacher and student. Administrative simplicity is also essential. In remote rural areas which lack electrification the management of education by transitorized video tape players and a tape library might be beyond the capabilities of some less developed countries. The technical requirements of maintenance alone could make a new technology impractical if adequately skilled technicians were not available.

Also a desirable medium must be communicable, easy to describe and demonstrate to potential users. Those innovations whose educational relevance is most apparent and demonstrable will spread most rapidly.

Finally, a desirable medium is one on which an integrative program of research is possible. That is, research and development must clearly be capable of being applied and a workable plan for meaningful application must exist. Many pilot projects and demonstrations are concerned only with short-term, temporary efforts that, although judged superficially successful, may have few if any long-range effects. Research projects in instructional technology should include strategies for application that have the endurance and pervasiveness of various United States "agricultural models" of research. That is, the research leads to the setting up of experimental stations, and they lead to experimental farms, and they to model farmers along with a network of change agents such as county agents and home economics demonstrators. Each research, if successful, should produce a growth point which is sustained until desired and significant change result.

6.3 Selecting educational procedures by estimating their costs and acceptability. The final selection of an instructional procedure or technology for research and development must be in terms of a subjective evaluation of the feasibility of employing it in a less developed country. In order to make such an evaluation each proposed area of research will be examined in terms of each of the criteria discussed above. First the monetary costs will be estimated, including the expected costs of development, implementation, and maintenance. Then each area of research will be examined for its acceptability to various actors in the educational process--the students, the teachers, the educational and political administrators, and the societies at large. The ultimate question is whether the study will be more than a pilot project, leading from research and development to application to enduring change of a desirable sort.

In determining feasibility of new educational procedures their perceived characteristics are important as well as their objectively defined characteristics. The perceptions of the persons who will be involved with them will decide whether they will actually ever supplement or replace the present procedures that are currently failing to provide adequate education for the citizens of the less developed countries.

Based on the foregoing analysis, each potential area of research will be either eliminated from consideration or included as feasible. The analysis will also help to determine the priorities of the feasible studies. A proposed research topic with medium monetary costs but low perceived relative advantage, for instance, would either be eliminated or given low priority.

## 7. Facts about Various Alternative Educational Procedures and Instructional Technologies Relevant to the Setting of Priorities Among Them

7.1 Nontechnological alternatives involving only changes in the human system. Inadequate attention has been paid to the nontechnological alternatives in educational reform, types of personnel employed, and sorts of instructional procedures used. Educational planners have concentrated on deciding what investments in research are needed to use more effectively the modern information processing technologies in education. This concentration avoids two issues: What nontechnological changes in educational practices are possible? And how can one combine changes in human components of the system with the introduction of new technologies to produce more effective educational systems? As an unpublished AID paper has pointed out, "there are not yet extant complete systems which are of sufficiently broad scope and low enough in cost to serve as models for developing countries."[17] It is therefore essential that research into nontechnological innovations in education be pursued both independently of and in concert with research into the applications of technology. Not enough is known in less developed countries about the impact of teachers' education levels, student/teacher ratios, and the length of the school day on learner performance. A number of alternative combinations of teachers, paraprofessionals, students as teachers, and media should be considered for their comparative cost-effectiveness.

It is particularly important in less developed countries that suffer from a great shortage of fully trained teachers, to review the rôle of the teacher and to discover whether a good learning environment can be provided inexpensively by some combination of media and paraprofessionals. Traditionally the instructor has been expected to be the possessor of broad knowledge and to be able to answer any question one of his students might ask. He is also expected to be a model of the upstanding and educated man whom his students can emulate, the enforcer of justice in all intraschool disputes, and a paragon of virtue and good judgment. He is for the most part the sole judge of each student's worth and is vested with the power to transform that judgment into recognition and status for the capable or favored and into shame and possibly punishment for those who do not measure up. The teacher is traditionally responsible for the organizing, structuring, and provision of activities for up to six hours of the student's day. To some extent he may also be a counselor, parent surrogate, and governmental official.

The role of the instructor, however, is not static. Modern educational philosophy has shifted from the teacher-centered classroom to the student-centered classroom. The teacher's function has been transformed in many instances from the bearer of all knowledge to an organizer/administrator who provides the materials from which the students can learn what they need to know--a trend particularly outstanding in mathematics and science, the so called "discovery sciences," in which the instructional materials are, or have within them when properly manipulated, the message. In modern mathematics, for instance, manipulating concrete objects, rather than listening to the voice and watching the writing of the teacher, may be the best way for the student to perceive the nature of mathematical operations. Another change in philosophy has been the reorientation from learning facts to learning to think. With this shift in objectives the teacher talks far less and the students much more.

Such changes make it perhaps more likely that the media can provide more of the content to be learned while the teacher or a paraprofessional acts more to facilitate the learning process and apply an understanding of group dynamics to manage the learning environment. Replacing the instructor with media, or taking the primary responsibility for instructing away from the person who is physically present in the classroom may have effects on education which we cannot now foresee. Among other things it may be that these will be major strategies for cutting the costs of mass education.

7.2 Instructional technologies. The first two modes of teaching listed in Table 7 on page 117 tutorial sessions or small group discussions and class lectures, depend exclusively on local talent. In many of the less developed countries the teachers in many of the schools are untrained or only partly trained. The quality of instruction can never exceed their capabilities. All the other media have the potential of improving educational excellence by importing information and instructional procedures from experienced and perhaps outstanding teachers outside the school. This possibility of rapid improvement in quality is perhaps the greatest argument for the use of the new technologies, although the possibilities of greater individualization of instruction and of lower costs are also potent arguments. Let us now review the arguments for and against each of the 40 technologies listed in Table 7, identifying those with major promise and those which at present seem less satisfactory.

7.2.1 Relative promise of the technologies. Commenting in turn on each of the media in Table 7, we can briefly summarize their apparent present promise for education in less developed countries:

1. Tutorial sessions or small group discussions are very expensive compared with traditional classroom teaching, and to be at all effective they require trained teachers.

2. Class lectures are expensive, though less so than tutorial sessions or small group discussions. If class instruction is to be reasonably good, the teachers must be trained.

3. Lettering, writing on blackboard, charts, diagrams, graphs, maps, and such media usually require trained teachers for quality instruction. Some, however, have built into them enough instruction that they can provide learning opportunities with less qualified instructors. Their costs are relatively low.

4. Stage scenery sets are of limited value in education as a whole because they are used primarily in dramatic arts. Their costs are relatively great.

5. Written papers, documents, books, workbooks, tests, programmed textbooks, other printed educational materials, newspapers, journals, computer print-outs, Braille writings, and punched paper tapes have been used in a wide range of educational situations with demonstrated effectiveness, but for large numbers of students they are relatively expensive to reproduce and distribute. Programmed textbooks and other similarily programmed documents have certain advantages over the other media in this category in that a student can interact actively with the inputs, giving an answer to questions and then learning from the document whether the answer was correct. Also individualized "branching" is possible. Such programmed documents share these characteristics with two other sorts of media discussed below, teaching machines and computerized programmed instruction.

6. Demonstrations are valued primarily in the scientific fields and so are specialized media.

7. Dramatizations are applicable primarily in theatrical arts, and they are costly. There is no complete substitute for them, however.

8. Exhibits are of limited applicability to a specialized range of areas, especially the physical sciences, natural history, history and anthropology, and the technologies.

9. Field trips are of limited applicability to a specialized range of areas, geology, natural studies, and various applied arts. In addition they might be quite expensive.

10. Photographs and filmstrips are fairly expensive to reproduce and difficult to distribute. They offer no opportunity for active interaction by the student or individualized "branching." They have none of the advantages of audio signals or of motion.

11. Teaching machines are a major medium, because of their flexibility. As yet they are not sufficiently cheap to be broadly useful in less developed countries, but it is probable that, either in a noncomputerized or computerized form, teaching machines will ultimately have great impact for such mass instruction. They share with programmed textbooks, mentioned above, and computerized programmed instruction, mentioned below, certain special characteristics of all programmed instruction, such as that a student can interact actively with the inputs and that individualized "branching" is possible.

12. Silent motion pictures are expensive to reproduce and to distribute. They provide no opportunities for active interaction by the student or for individualized "branching." They also do not have the advantages of sound. They can be distributed less expensively over television networks and when so used have essentially the same advantages as video tapes.

13. Filmstrips or slides with audio tapes are fairly expensive to reproduce and to distribute. They offer no opportunity for active interaction by the student or individualized "branching."

14. Sound motion pictures are expensive to reproduce and to distribute. They provide no opportunities for active interaction by the student or for individualized "branching." They can be distributed less expensively over television networks, and under those circumstances they have many of the advantages of taped television.

15. Telephone network transmission costs are high for educational uses. In less developed countries telephone networks often operate poorly. In some areas they are nonexistent. This medium does not have the advantages of video signals, but it is as yet unclear whether video signals significantly improve the learning environment.

16. Broadcast live instructional radio is a major medium. It does not permit active interaction by students or individualized "branching." It does not have the advantages of video signals, but, as noted above, it is unclear whether and to what extent video signals improve the learning environment. It is potentially inexpensive, $0.01 to $1.00 per student hour.

17. Telewriting and telewritevision are interesting new media, as yet not widely used. They are not portable, and the equipment necessary for receiving the signals is relatively expensive. Students can interact actively with the input only if there is a feedback channel for audio signals, and this means that essentially two channels in one direction and one in the other are required, a total of three telephone channels. This is expensive over long distances, and in addition, as noted, telephone networks in less developed countries are often poorly operated and at places are nonexistent. Furthermore, telewriting on the screen is often distracting to students watching the process, since the pattern builds up slowly. Of course it is also true when a teacher writes on the blackboard that the students' time is wasted while they wait for the words or pictures to be formed. Telewritevision requires local visual materials, which must be transmitted by mails or by other means that are relatively expensive. Often the signals on these media are not clear. These media employ limited bandwidths and consequently do not have the advantages of media that depict free motion. Probably they will be replaced by other media wherever greater bandwidth becomes available

18. Audio tapes, cassette, cartridge, and record players do not give a student an opportunity to interact actively with the input and do not allow for individualized "branching." In addition they do not have the advantages of video signals. If they are used on an electronic network, they have the same advantages and disadvantages as radio.

19. Dial-access audio tapes constitute an expensive medium. The networks over which remote access to the tapes is obtained are also expensive to operate. As noted above, long distance telephone networks are not always well operated or even in existence in less developed countries. Sometimes, of course, dial-access is provided over limited networks in a single school or locality.

20. Teletype and telegraph are relatively expensive media. Networks over which the signals pass are expensive to operate and must be in existence. This is not always true in less developed countries. Also the rate of input of information is restricted to about 40 to 50 words a minute and there can be only one or very few users at a time at each terminal.

21. Closed-circuit audio lectures can take advantage of talent available in an entire school rather than a single classroom but inputs cannot originate from other locations. Only students with speakers connected to the circuit can hear the lecture--it is not broadcast to an entire community or region. This medium does not permit a student to have active interaction with the inputs and it does not permit individualized "branching," any more than classroom lectures do. Also it has the disadvantage of providing only audio signals. On the other hand, it is less expensive than single classroom lectures.

22. Radiovision is an expensive medium, requiring some form of delivery of the visual materials from a central source to the remote place where they are used. Also it provides no visual motion and there is no individualized "branching."

23. Slow-scan TV is a narrow-band medium which provides a series of still pictures, but no motion pictures. The buildup of the pictures is slow. While this is going on the attention of the student is easily distracted from the concomitant audio inputs. Often the video signal is not very good. The technology has not been thoroughly tested. There is no individualized "branching." Also it is dependent upon the existence of a telephone or alternating current network, which may not be present in a less developed country or which may carry a poor signal.

24. Broadcast live TV is a medium of major importance, the one to which most attention is now being given in less developed countries. It has certain shortcomings. No individualized "branching" is possible. If used with mass audiences it is potentially cheap in terms of the cost per student hour, but it is still more expensive than radio because the receiving sets are more costly. Maintenance and provision of the necessary electrical power may be difficult in less developed countries.

25. Closed-circuit live instructional TV has the same characteristics as broadcast live instructional TV, except that it is limited to local talent and all viewers must be connected with the network--the signal is not broadcast to an entire community or region.

26. Broadcast tape-recorded instructional TV has the same characteristics as broadcast live instructional TV, except that a student cannot interact actively with the input, as he can with live broadcast TV if an audio feedback channel is provided.

27. Closed-circuit tape-recorded instructional TV is just like closed-circuit live instructional TV except that a student cannot interact actively with the input.

28. Facsimile transmission is an expensive medium. It requires existence of a good telephone network, which may not be available in less developed countries. Moreover, the specialized accomplishment of this medium is to shorten to minutes the delivery time over distance of printed or graphic documents. Such speed of delivery is not vital to primary or secondary educational systems, although it possibly may be for higher educational activities in which the demand for scholarly materials is not predictable. It could be especially valuable in nations that do not have an adequate network of scholarly libraries.

29. Audio pointer is a little-known and as yet relatively untried method with many of the characteristics of teaching machines. It does not have the advantages of visual motion and a student cannot interact actively with the inputs. It is fairly expensive.

30. Phonevision requires a wide-band telephone network, a coaxial cable network, or similar wide-band channels which are ordinarily not available in less developed countries. Also it is expensive.

31. On-line computer aids to learning and scholarship are too expensive at present for use by less developed countries. They are far from being perfected, and are of value primarily to higher education.

32. Instructional computerized games and simulations are too expensive at present for use by less developed countries. They are far from being perfected, and are of value primarily to higher education.

33. Computerized programmed instruction is a major medium because it constitutes an extremely flexible learning environment. It shares with other forms of programmed instruction, mentioned above, programmed textbooks, and teaching machines, the capability of enabling a student to interact actively with inputs and of permitting individualized "branching." It is still too expensive for less developed countries, but its costs are going down rapidly and attempts are beginning to be made to employ it in less developed countries. The costs are likely to fall within the next few years to such a point that serious consideration of this medium is justified. This will also be true of teaching machines which have similar characteristics although not the flexibility of computer-aided or computer-managed instruction.

34. Video tape or disc players constitute a major medium with the same advantages and disadvantages as TV except that a student cannot interact actively with the inputs. Distribution costs of the video cassettes or discs are high and maintenance may constitute a serious problem. There are certain special advantages of this medium, including the fact that scheduling of the use of programs can be controlled locally. Also the rate of input can be controlled by an individual student and he can reverse the program and play it over again. At present this new medium is quite expensive, from $0.25 to $2.00 per student hour, but this can go down quickly, especially when efficient disc recorders which are similar to phonographs but which play video programs on ordinary TV sets come on the market.

35. Video language laboratories. These are largely untried as yet, and are certainly too expensive at present for less developed countries. It is uncertain whether concomitant video and audio signals are better than audio signals alone in language learning.

36. Computers which output visual words and numbers, moving and still pictures, and audio language are still experimental and are too expensive for less developed countries.

37. TV information storage is still experimental and too expensive for less developed countries.

38. Holographic information storage is still experimental and too expensive for less developed countries.

39. Instructional interactive TV or time-shared TV are still in the experimental stage and too expensive for less developed countries.

40. Dial-access instructional TV is still in the experimental stage and too expensive for less developed countries.

Out of the 40 sets of media listed above, there are, then, five major instructional technologies with particular promise for education in less developed countries. These are broadcast live instructional radio; broadcast live instructional TV and related media; audio tape, cassette, cartridge, and record players; video tape or disc players; and programmed instruction, including programmed textbooks, teaching machines, and computerized programmed instruction. We shall now discuss each of these in order.

7.2.2 Broadcast live instructional radio. Radio clearly is among the major instructional media. What has radio contributed so far to nonformal and formal education? How effectively has it performed in actual and experimental settings? How does radio compare in costs and effectiveness with other media, particularly TV?

The development of instructional radio in the United States has a long and arduous history. In 1919 the first educational radio station, WHA at the University of Wisconsin, went into operation. Through the years numerous licenses have been issued to new stations and many of them have later disappeared. Educational broadcasters, commonly unsupported by the educational administrators, the press, the government, or their commercial counterparts, have found survival to be extremely difficult. It was not until 1949-50, in fact, that the educational radio received the necessary support from philanthropists and foundations to establish the continuing programs from which today's educational broadcasting has grown.

In Britain, on the other hand, radio from the beginning was considered more of a public service than a commercial enterprise. Regular school use of radio was supplemented in 1939 by BBC broadcasts which taught English as a second language. Today these broadcasts teach elementary and secondary school English in over 60 countries. As early as 1958 Japan, Austria, and Germany were operating "schools of the air." Australia's exemplary schools of the air simulate the communication techniques of the classroom so effectively that children perform plays in full costume at isolated cattle stations hundreds of miles apart from one another.

To what extent has the radio been used to meet educational needs in less developed countries? Many less developed countries are using radio as a means to supplement both their formal and their nonformal educational systems.

India, Brazil, Ethiopia, Togo, Malawi, Honduras, Colombia, Niger, and Morocco all use radio to bring some combination of health, agriculture, literacy, and community action programs to segments of their populations. These programs vary widely in their dependence on radio, and the degree to which the audience is actively involved in the programming. For example, in the radiovision literacy program in Niger, radio is used simply as an aid to the basic skills of the instructor. In Colombia and Honduras, however, an educated member of the community who can read and write acts as a monitor in the use of the radio. There is no other teacher. Radio clubs in Togo, Niger, and India are essentially rural action forums which encourage participants to organize, respond to, and act on the content materials broadcast.

In many countries radio is used as enrichment in the classroom. Less common are structured correspondence schools which offer courses to those unable to attend or complete secondary school. Japan, for example, provides an admirable model for this method of expanding educational capacity when the necessary physical facilities and/or financial resources are unavailable. Both Kenya and Malawi are now involved in such programs. Some countries--Algeria, Brazil, Thailand, and Colombia, for example--are exploring the possibilities of radio training for teachers, either, as in Thailand, as an adjunct to the use of radio in the classroom, or, as in Colombia, to give teachers the equivalent of a four-year course, preparing them for the teacher-training examination.

Has radio been an effective educational medium in the contexts in which it has been used? There are several examples of outstanding performance. The European and Australian schools of the air seem to have brought many students educational opportunities which match in quality what they could have had in the classroom. Colombia's Radio Sutatenza has successfully trained teachers, has provided rural literacy training, and has been responsible for an impressive number of community development and agricultural improvements. In general, however, educational radio has not lived up to its potential. Most educational radio stations program for the general public and the programming must be broad enough to appeal to a general audience. Most programming emphasizes classical music and public interest issues, ignoring more academic or informational subject-matters. The budgets of most educational stations reflect their lack of public or institutional support. The use of radio in the schools of the United States has been insignificant compared to the use of filmstrips, films, records, and more recently, tapes and TV. As a result even programming for school use has been designed to appeal to a large heterogenous, general audience, which means it is less than ideal for instructional purposes. Often programming that attempts to serve a wide audience will result in only a few programs which are appropriate for each component of that audience.

Up until this time most programming for educational radio in less developed countries has been planned for use as supplementary instruction in the classroom, rather than to present the core of the substantive materials. It does not, therefore, constitute an integrated, independent unit of study but rather enrichment of the regular classroom activities. Also educational programming in the past has usually tried to stand on its own, without the support of any workbooks or other curricular materials. It has relied only on the classroom teacher to reinforce and follow up the broadcast learning experience. Often the teacher considers the broadcast to be a self-contained experience and leaves it completely unsupplemented by discussion or reinforcement so that the student does not get optimal benefit from it.

In the recent surge of new media in education, radio seems to have been forced into the background by TV and other showier media. It has been assumed by some that the more sensory modalities a medium can appeal to, the greater can be its effect on learning. Color pictures are better than black and white, moving films than filmstrips, sound films than silent, and television than radio. On the other hand, some studies have indicated that in many cases multimodality presentation increases effectiveness only within limits, and beyond those limits actually may reduce learning by presenting irrelevant and distracting stimuli. It has been found that learning through aural channels may be significantly reduced when the aural material is supplemented with a visual presentation.[18]

A study of college students learning about the structure of preliterate languages compared the effectiveness of radio, TV, class lectures, and print with and without the supplementary use of audiovisual aids. Without teaching aids television was a better teaching medium than radio, but both were better than class lectures or print. With teaching aids, both TV and radio were better than print and lecture, but radio was more effective than TV. Apparently television was less effective than radio because the latter elicited more active involvement of the students in the presentation process.[19]

A study of reading comprehension by Travers and Jester, found no significant difference among video, audio, and audio-video presentations at rates up to 200 words a minute (a greater speed than normal speech). At speeds greater than 200 words a minute, audiovisual presentation was more effective than either audio or visual, and the effectiveness of the audio presentation decreased more rapidly than the visual as the speed of presentation increased.[20] Indications are that one audio channel delivers information at about the rate that a listener can assimilate it, whereas TV often bombards the listener with redundant or irrelevant information which may constitute an overload.[21] Therefore, at times certain media are employed, usually television, to do a job which radio could do more effectively and at lower cost.

In teaching subject-matter such as music or language, a picture on the screen may be only distracting. In some styles of presentation, such as the lecture, the facial expression of the lecturer provides marginal or irrelevant additional information over what the voice conveys.

How does radio compare with other media in costs? The costs of radio, estimated in comparing potential satellite radio and TV programs in Brazil, are between one-third and one-quarter the costs of TV.[22] Two basic costs were included in these estimates: costs of the hardware and the costs of the printed materials to be used with it. The hardware costs include satellite design, the construction of two satellites (one a spare), the launch, 200,000 ground stations, and monitors. Annual expenses for hardware were estimated at 20 percent of the initial cost for financing plus 10 percent for operating, or a total of 30 percent of the initial cost annually.

A recent design study, MISSAC, done at the University of Michigan, estimated the costs of a 30-channel instructional radio system.[23] The study estimated the total costs of radio hardware of a 50-channel system at about 90 percent of the TV hardware costs with annual costs at 30 percent. The big difference between the radio and the television systems is this:

at a comparable level of investment, only 10 percent of the students could watch TV at any one time. Because of the high cost of TV sets, the program was limited to one set for every 20-50 students, or two to a school. Therefore only 2 channels are used. On the other hand, the 50 channels estimated for the radio system can easily give more than enough broadcasting capacity for all the students to be taught by radio the entire school day. However, two students by this plan are assigned to each pair of earphones, so only half the students can listen at any one time. Even at that, five times as many students can listen to radio as could watch TV, and at less cost.

A major cost of the radio system as projected was the associated printed materials. They cost more than 25 percent of what the hardware cost, whereas the associated printed materials for television cost much less than for radio. The total effective monetary cost of radio was estimated to be between one-third and one-quarter that of TV.

A multiple-radio channel satellite system offers distinct opportunities to groups of less developed countries within the same geographical area. They could share a single satellite. Such a system would go a long way toward extending the benefits of scarce resources. In multilingual regions, like India, such a system would make possible simultaneous multilingual broadcasting.

In another study Jamison, Ferras, and de Sousa concluded that six TV channels on the Hughes satellite HS-307 could be replaced by approximately 1,000 radio channels.[24] On these 1,000 channels a branching radio programming system could be broadcast which would enable a student to begin using the program, rapidly determine his own stage of educational advancement, and by answering questions periodically proceed through a course of instruction at his own pace, using as a coordinated learning aid a programmed workbook containing printed and pictorial materials.

What can be done to enhance radio's effectiveness as an instructional tool? The most basic problem in the past uses of radio is that it has been inadequately supported by other media and materials. It has usually been expected to do a job which it cannot do--provide high quality instruction in isolation. The greatest promise of instructional radio lies in its ability to present high quality teaching at relatively low cost when used in conjunction with other educational tools.

Particularly interesting is the ability of radio to introduce innovative and unfamiliar curricula successfully in less developed countries. When less developed countries engage in modernization of their curricula, it frequently turns out that the teachers are unable to present the new materials. Because the educational system must continue operations, it is often impractical to release teachers for retraining, although sometimes this can be arranged. Take, for example, the Entebbe Series of modern elementary school mathematics textbooks, cooperatively developed by ten African countries. This series, although completed, has not been introduced into school systems on a large scale because few teachers were able to present the materials. It has been proposed that the teachers be trained for this program by three-day workshops. Then the students would be taught by a radio broadcast tutorial course.[25] Immediate but partial feedback would be provided by giving up to 50 percent of the answers to problems over the air. The teachers' responsibilities would be primarily administrative and organizational.

Language teaching is another area in which radio has great potential. In the past the BBC and other broadcasts have been used for second language learning. These programs have usually been supplementary and general. For the most part they compress too much content into too few lessons. Because of a shortage of available broadcasting time, the lessons often proceed at a pace too rapid for the students. Coordinated written and pcitorial materials, accompanied by tape recorded spoken sentence patterns and practice songs, jingles, nursery rhymes, dialogues, and question and answer exercises for broadcast, may well be the most effective method to introduce new language curricula in less developed countries. For the most part untrained teachers in developing countries, themselves not very capable or entirely comfortable in the language being taught, depend on reading and writing rather than oral communication as their medium of instruction. A systematic radio broadcast program could introduce modern language curricula to teachers as well as provide large numbers of students with the opportunity for first-rate language learning, and hopefully train teachers in these techniques by providing fluent, accent-free models of speech.[26]

The primary unresolved question about instructional radio is whether it is as effective in providing a learning environment as TV. If it is not, is TV sufficiently better to justify the extra costs to a less developed nation? The budgets of some such nations may at present be so limited that they can afford only radio. How much do they lose by such restriction? The original cost of radio transmitting and receiving equipment is much less than TV equipment. Radio requires less bandwidth. Radio maintenance is cheaper. Educators in some less developed nations resist programs using radio and prefer TV. Is this faddism or is TV so much more effective that their views are justified? The evidence is not yet all in.

7.2.3 Broadcast live instructional TV and related media. It is obvious that TV is a major instructional technology. It is getting more consideration and being used more widely today than any other one of the new information processing media.

Traditionally, a teacher has been expected to act as a source of information, a role model for students, and an evaluator of their performance, a counselor, a parent surrogate, and a governmental representative, as we mentioned earlier. Television can carry out at least part of all these activities. Almost all research into educational television, however, has had the purpose of determining whether it can adequately convey the subject-matter of academic curricula to students.[27] The importance of television in providing role models, entertainment, and information on governmental activities has been examined in more general investigations into the effects of mass media on the general population.[28]

The most significant result of the studies of the effectiveness of instructional television in transmitting information is that "children and adults learn a great amount from instructional television, just as they do from any other experience that can be made to seem relevant to them."[29] This has been demonstrated, for example, in Hagerstown, Maryland; Italy; the Ivory Coast; Peru; and Colombia. More specifically, Chu and Schramm reviewed 207 published studies up to 1966 in which television teaching was compared with conventional teaching. Most indicated no significant difference between the two. The results suggested that students learn at least as well from television as from conventional teaching.

How effective instructional television is, as compared with alternative means of teaching, is a much more complicated question. The best example of an answer the authors of The New Media: Memo to Educational Planners could offer is the following:[30]

> "Samoa is not reducing its school budget by adding television; indeed, it has greatly increased it. But Samoa is betting that with television it can very substantially raise the (qualitative) level of its schools much faster than would be possible by the only other really feasible method considered available--a long-term programme of teacher training and replacement."

Since the Memo was written a number of fairly sophisticated planning studies have been conducted to examine the comparative cost-effectiveness (both unit as well as cognitive cost-effectiveness) of instructional television systems. Two kinds of investigations have been conducted. Initially, proponents of instructional TV wished to investigate its comparative cost-effectiveness as compared to traditional means of upgrading education. An excellent example of this approach is the Rand Corporation's analysis of four alternative ways one could substantially upgrade primary and secondary education in Colombia. One of the ways is instructional TV.[31] In this study, the effectiveness of all the alternatives is assumed to be roughly the same. The choice then rests on cost considerations. Television in Colombia was found to be a very competitive alternative if there were to be large increases in enrollments. Based on the present TV experience in El Salvador, Speagle arrived at very similar conclusions.[32]

The other kind of cost-effectiveness study centers on the comparative cost-effectiveness of alternative instructional television systems. Most such studies have examined the potential use of communications satellites for instructional TV. One example of such an effort is a study on satellite-distributed educational television in India and Latin America conducted by Schramm and Platt in 1968.[33] The authors compared three basic distribution systems--a ground-based microwave network, a rebroadcast satellite system linking ground-based transmitters with augmented television receiving sets, and a third alternative, one for Latin America and another for India. They concluded that the satellite system exhibits declining unit cost per student served with increasing coverage. The other systems exhibit rising unit costs after the population residing in densely populated areas has been served.[34] The real choice among these alternatives depends, then, on the specific demographic and geographic characteristics of any nation considering an instructional television system. Similar studies have been conducted for Brazil and India.[35]

The studies in India have concluded that the satellite approach is less expensive than a conventional TV network. While these analyses must certainly have been useful in the decision to go ahead with a satellite system for India, they demonstrate the major shortcoming of most cost-effectiveness studies in the use of television for instruction which have been done up to the present: effectiveness is almost always assumed to be the constant, leaving the analyst with only a cost comparision to make. Because there are unknowns involved in determining costs, different analysts can come up with markedly divergent rankings for any set of alternatives.[36] Therefore, it may be that, as Butman points out, "one can demonstrate (in the case of India) that conventional system costs may be close enough to satellite costs so that the choice can be made on effectiveness alone."[37] If this is the case, and it certainly must be in comparing some alternatives, then planners must tackle the problem of effectiveness just as diligently as they have tackled the problem of costs. This does not seem to have happened yet in the selection of educational television systems. The following fictional example makes television's basic case for cost competitiveness. It is obviously not conclusive, but indicates the logic.

Assume an educational system of 10,000,000 elementary and secondary students, 250,000 teachers with a student/teacher ratio of 40. Average annual salary and benefits per teacher per year is $2,000. Therefore total payroll for teachers is $500,000,000. If teachers' costs constitute 80 percent of the total educational costs, the total annual educational budget is $625,000,000. Now assume we do not fill teacher vacancies when they occur from normal growth or from growth of the system. (We do not discharge any teachers, however, since this would probably be politically unacceptable.) With the salary funds saved we buy TV equipment.

A classroom-size TV receiver, or a smaller set and several monitors for small group viewing, will cost about $1,000 for a class of 40. Since there are 10,000,000 students, there will be 250,000 classrooms with 40 students each. The total cost of receivers for 250,000 rooms at $1,000 each will be $250,000,000. Each broadcast channel costs about $200,000 per annum to operate. Therefore, assuming 50 channels, we have total annual operating costs of $10,000,000. Each channel is programmed for 10 hours a day, 200 days a year, or 2,000 hours per annum. At a conservative programming cost of about $1,000 per hour, the annual programming cost would be $2,000,000 per channel per year, or $100,000,000 for all

50 channels. Assume 10 percent of total costs for maintenance, training, and management. The total annual budget for TV instruction then would be:

| | |
|---|---|
| TV receivers for 250,000 classrooms............... | $250,000,000 |
| Programming costs for 50 channels................. | 100,000,000 |
| Operating costs for 50 channels................... | 10,000,000 |
| Maintenance, training, management................. | 40,000,000 |
| Total | $400,000,000 |

This total equals the annual salaries and benefits of 200,000 teachers, compared to the $500,000,000 currently spent for salaries and benefits of 250,000 teachers.

Assume that the $400M spent on instructional TV may offer instruction equivalent to that provided by 200,000 teachers, though of better average quality.

We then have four pure alternatives:

(1) Increase instructional capacity

from $10^7$ to $10^7 + \frac{200,000}{250,000} \times 10^7$ or $1.8 \times 10^7$, an 80 percent increase in the number of students or of instruction hours per student. This will increase the annual budget by $400,000,000, to $1,025,000,000.

(2) Decrease the student/teacher ratio from 40 to $\frac{40}{1.8} = 22$. This also will increase the annual budget to $1,025,000,000.

(3) Decrease the number of teachers. This would have to be done gradually and would be politically difficult or impossible, but the number could be reduced from 250,000 to 250,000 - 200,000, or 50,000 for the same total budget and same number of instruction hours, only 1/5 of which would involve direct human contact.

(4) Retain the present traditional system

The crucial questions in terms of these pure alternatives, are: Is the decrease in student/faculty ratio from 40-to-1 to 22-to-1, or the 80 percent increase in student capacity or instruction hours per student "worth" 400/625 or about 65 percent more in annual expenditures? And would the quality of instruction be better with 50,000 teachers and $400,000,000 of instructional TV as compared to 250,000 teachers and no TV?

There are also issues of academic quality to be argued:

Will instructional TV, by its constant demand for new program material, stimulate continuous curricula reform and thus ultimately elicit major educational improvements?

Will instructional TV, by its ability to present real-time events, shift instructional emphasis from subject-matter that changes slowly (mathematics, science, or languages) to that which changes frequently (technology, politics, economics, lively arts)?

Will instructional TV enhance teaching as a career by offering wider scope to master teachers who will be able to reach more students, or degrade it for the many teachers whose instructional role is partly supplanted?

Using television as an information source for instruction has been shown to be effective and, for mass instruction, financially sound. There is also a good deal of information on the best mix of factors for an effective instructional television system in Chu and Schramm's well known report. 38 It is difficult to summarize their comprehensive findings briefly, but the following are among their major conclusions:

(1) Instructional TV's effectiveness depends on the integration of television into a suitable context of learning activities of the student.

(2) In skill training, a subjective view on the screen is more effective than an objective view.

(3) Attention-gaining cues, as in commercial advertisements, that are irrelevant to the subject-matter detract from effectiveness.

(4) Visual magnification, color, and many production techniques, *e.g.*, lighting, sets, do not greatly influence the effectiveness of instructional TV.

(5) Subtitles tend to improve learning from instructional TV.

(6) Questions inserted in a program do not improve learning, but rest pauses do.

(7) The use of humor, animation, dramatic presentations, permissive attendance, teacher eye contact, and the place of the broadcast in the lesson period do not greatly influence the efficiency of instructional TV.

(8) TV programs can probably be shortened when necessary without greatly damaging program effectiveness.

(9) Lectures, interviews, and panel discussions are all likely to be about equally effective forms of presentation.

(10) Instructional TV appears to be equally effective with small and large viewing groups.

(11) Proper motivation for learning from TV has an important bearing on the effectiveness of instructional TV.

(12) The impact on homogenous viewing groups and home or classroom viewing seems to depend on other factors.

(13) The lack of prompt feedback to the instructor does not seem to hamper learning from TV.

(14) The lack of learner opportunities to discuss and question the program and to know how she or he is doing as the program goes along impairs the effectiveness of instructional TV.

(15) There is insufficient evidence to suggest that the lack of student-teacher contact will impair learning from instructional TV.

(16) Appropriate practice during the lesson will improve learning from instructional TV if it does not constitute an interference.

(17) The academic grade at which instructional TV is used has a bearing on attitudes towards it.

(18) Administrators tend to be more favorably inclined towards instructional TV than teachers.

(19) There is insufficient evidence to conclude that some subjects should not be taught by instructional TV.

(20) The Hawthorne effect (improvement in learning as a result of the extra attention students receive in an experiment) seems to operate in the use of instructional TV, but its impact on learning, if any, is not known.

(21) A number of factors that determine teacher and student attitudes toward instructional TV have been identified (They are listed in the report).

The research findings summarized above have contributed to the proliferation of activities in instructional television in the last few years. However, as new projects have gotten underway, other factors have been identified and investigations of them started.

The research studies summarized above deal chiefly with the interaction of the student with information inputs in a classroom setting. There is, however, a much greater set of variables to consider in TV instruction. The following areas of concern have all received inadequate attention:

- The organization and procedures of materials development (including the need for feedback on lesson effectiveness)
- The training of teachers to use ITV
- The factors related to the organization of the system's management
- The nature of the teacher's follow-up activities
- The design and development of the equipment used
- The social, cultural, and psychological characteristics of viewers

Only in the current AID-sponsored research effort in El Salvador have some questions about these latter factors begun to be investigated in anything like a systematic manner.

Besides their concern for the effectiveness of the educational reform in El Salvador and television's contribution to it, the researchers from Stanford's Institute for Communication Research have focused on two areas of investigation mentioned in the last paragraph: (1) the organization and procedures of materials development and (2) the training of teachers to use instructional TV.

The first year's results in organizing an instructional TV materials development program were far from ideal. According to the summary of the first year by the researchers, McAnany, Mayo, and Hornik:[39]

"The administrators of the ETV section (in El Salvador) struggled with the difficult tasks of coordination and scheduling throughout the first year of broadcasting...Production materials were often not delivered on time, film was not processed rapidly enough, and the studio lost electrical power with alarming frequency. These physical handicaps were compounded by the presence of a relatively inexperienced production staff which was expected to learn new skills on the job." No organized research has been conducted into the human causes for these problems and no strategies for overcoming them in other settings have been suggested. After the first year, however, programming procedures were improved and formative feedback from classrooms began to come to the program producers.

According to the Stanford team "tests were developed, pretested, and administered by television near the end of a given unit of the course, and results were reported to the studio in time to permit the preparation of special review or remedial broadcasts."[40] This feedback system was tried on an experimental basis and is now being further expanded. Still, a number of problems remain to be overcome in the application of this specific feedback system. The Stanford report lists six such problems:[41]

(1) The lack of experience or training in modern test construction.

(2) A severe limitation on the number of letters that can be presented at any one time on the television screen.

(3) Poor timing of test questions administered over the TV.

(4) The need for more rapid and efficient collection of test results.

(5) The need for feedback about student performance to improve program quality.

(6) The need to provide just the right amount of adjustment in programs when responding to feedback about student performance.

One could add to this list the problem of whether or not TV is the best means by which to administer the examinations that will serve as the source of learning results. The authors of the El Salvador report present some cogent arguments for using TV, but two of the six problems they list (lettering and timing) concern constraints on TV testing. Other testing means are certainly possible. For example, in Brazil the possibility of feedback using facsimile transmission of test documents has been discussed. The tests might be transmitted by TV when the class was not present, then printed, distributed, and collected locally. In any case, the use of feedback for formative evaluation and the improvement of any kind of instructional broadcast is still in its infancy.

The El Salvador project has also paid much attention to the preparation of teachers for the use of instructional television. One of the primary aims of the educational reform in El Salvador is the improvement of the teachers. To this end a major effort in teacher retraining has been mounted. About 900 teachers are being given a nine-month retraining course while a number of the qualified teachers, superior normal school graduates, are being given shorter training courses. The Stanford team has examined the attitudes of these groups and those of classroom teachers who have not been retrained. Their general conclusion is that:[42]

"Teachers using television in their classrooms showed very favorable attitudes toward television instruction at the beginning of the year and even more positive attitudes at the end. Two other teachers groups in retraining, who had not yet used television, were more skeptical but still positive in their attitudes toward ITV."

Since the bulk of the classroom teachers used television, this finding suggests that perhaps formal retraining away from the classroom is inappropriate for developing positive attitudes toward the use of TV. If this is the case, other alternative means of introducing classroom teachers to ITV must be identified and tried out, along with different support procedures.

The management decisions involved in implementing educational reform had a major impact on the success of instructional TV in El Salvador. The Minister of Education, Dr. Walter Beneke, took extraordinarily quick action in bringing about the reform. Soon after his selection as minister he appointed a commission to lead the rewriting of all the grade 1 - 9 curriculum. He implemented a complete administrative reorganization of the ministry. And he closed most existing normal schools, "a bold decision which had strong political repercussions."[43] In analyzing the role of TV in the reform, the Stanford group concluded that it acted as a catalyst.

An area that has received little research attention is how a teacher can select among alternative ways of introducing and following up TV broadcasts in a classroom or other instructional settings.

What kinds of in-class activities are best for reinforcing the information transmitted during a TV lesson? In El Salvador they found that the use of TV increases the amount of student activity in the classroom. Is this ideal? What is the best role for the teacher in relation to the TV lesson and the activities surrounding it? To what extent can TV lessons entirely replace teachers?

Most of the above discussion has concerned the instructional TV experiment in El Salvador. Because of its careful design and effective implementation, it is very instructive. There have been a number of other successful programs in other countries, however, and each one has its own characteristics. The Peace Corps ETV Project in Colombia, inaugurated in 1964, is a case in point.[44] Colombia is much larger than El Salvador, with a quite different culture. Its expansion was very rapid, from 38,000 to 260,000 students in two years. Its goals and procedures are much different. From analysis of a variety of such programs generalizations about the strengths and weaknesses of instructional TV can be made.

While it is known that color, visual magnification, and many production techniques have little bearing on the effectiveness of instructional television, there is still much research to be done into the optimal receiver design and into the best means of delivery. The present satellite projects in India and Brazil are cases in point. We have already cited some articles on the comparative values of proposed satellite transmission systems and their uses. While much has been done and some decisions made, further research is still desirable on the working capabilities of different transmission systems and the equipment used in them. Also, current disagreement and uncertainty over what the television receivers to be used in the Indian system will cost suggests that there is still work to be done in the design, development, and production of television receivers in developing countries.

Research into the impact of various social, cultural, and psychological variables on the effectiveness of instructional television has been inadequate. Most research on instructional TV has been done in the United States. Little effort has been expended on determining how the specific variables that describe individuals in different cultures and societies affect the impact of instructional TV. In a perceptive theoretical article, Salomon points out that "the same stimulus is differently perceived, decoded, processed, etc. by individuals who differ on a number of relevant characteristics."[45] With the exception of work done on visual perception, little empirical research has been carried out on the most effective combinations of inputs in learning settings for students in less developed countries.

Salomon places great emphasis on what he calls the "supplantation" effect of media on mental processes. By this term he means that the media carry out some cognitive process for the viewer. One would suspect that this supplantation effect would be different for variously acculturated people. For example, the nonreflective nature of most TV presentations might have little influence on the highly reflective cognitive processes of Hindus and Buddhists.

Visual perception does not seem to vary greatly among people around the world, but training in it does. There are other cognitive processes abstracting from experience, using language, and so forth, that are relevant to TV learning but have not, like visual perception, been investigated with relation to instructional TV. One of Salomon's conclusions is that "research on media needs to relate itself to research in other fields.[46] We agree. The established findings of anthropology, sociology, and psychology have not been adequately applied in analyzing the effectiveness of instructional TV in developing countries.

The foregoing survey of what is known about the effectiveness of instructional television has a number of gaps in it. First, the whole area of nonformal education--literacy campaigns, health and population programs, and agricultural extension work--has been neglected. Much of the knowledge we have about learning in schools applies to nonformal settings as well. Perhaps the greatest concern about nonformal education, certainly not adequately researched, is how to motivate adults to broaden their education.

The impact of instructional TV on the teacher's responsibilities as role model, counselor, parent surrogate, and governmental representative has not been dealt with. These are as yet untried areas of application of instructional TV. Possibilities exist for TV to increase a sense of national identity, to provide counseling on jobs and their availability, and to conduct a range of other entertainment and secondary learning activities. There is no question that instructional TV is a young giant in education. It is not the perfect instructional medium, for it does not permit the student complete freedom to schedule when and where it will be used and it does not provide individualized "branching" in any of the forms currently available in less developed countries. Nevertheless it has great strengths, most of them inadequately tested.

7.2.4 Audio tape, cassette, cartridge, and record players. First came phonographs. Their technical excellence gradually improved until with playing speeds as slow as 33 revolutions per minute and very precise stamping or casting of light, nonbreakable plastic discs, high fidelity long play records became available cheaply. Then there were expensive reel-to-reel tapes, capable of being played over and over again without losing their very high fidelity. Then cassettes and cartridges were developed. Their fidelity at first was poor but it has gradually improved with better tapes, better methods of recording, and better players. They were much cheaper than reel-to-reel tapes, could play for well over an hour if necessary, and were simple to load and hard to damage.

The players for all these forms of audio inputs were at first expensive, but in every case as they have improved in quality this demand for them has increased greatly and they have diminished in price. Now the electronics revolution, spurred by the transitor and Japanese competition, has produced hardy players operated on batteries or live voltage, which are compact, portable, remarkably dependable, long lived, and cheap.

The phonograph record has had limited instructional use outside the field of music. It has also been used for recording certain sorts of lectures, for poetry recordings, for language learning, and for recording the voices of historical figures and historical sounds. The tape media in general are more convenient to use than records and can be replayed more frequently without damage, so they are replacing records in many educational uses. Just as tapes in various formats are increasingly cutting into the phonograph record market in the fields of classical and popular music, so they are also in instruction. Their convenience, hardiness, and cheapness all are in their favor. Language lessons, lectures of all sorts, music, and whole academic courses are available on tape now, often accompanied by textbooks, workbooks, filmstrips, or slides.

It is interesting that, appropriate for education as these audio media are, they have been subjected to little investigation or evaluation. They appear to be admirable media from many points of view for less developed countries, even though they do not usually permit active interaction by a student or individualized "branching." Systematic research on their potential in specific educational situations seems clearly indicated.

7.2.5 Video tape or disc players. Three chief arguments for the importance of video recordings are that: (1) they allow for scheduling and viewing flexibility that real-time television does not; (2) the recordings, both cassettes and discs, are likely in a few years to provide inexpensive and easy to use broad band audiovisual materials which have the characteristics of color TV programs; and (3) the recordings can be made locally.

This medium cannot only be used for the education of students but research evidence collected in the United States and abroad suggests that both television and video recordings play a unique part in the training of instructors. They can provide a wide range of role models to the prospective instructor through the use of packaged materials and the presentations of many master teachers. This can greatly increase the counseling potential of teacher training. Also media which convey sound and visual motion are especially well adapted to the demonstration of teaching strategies and techniques, regardless of whether demonstrations are provided over television from a distant source or locally on video tapes.

We shall now briefly summarize what is known about video recordings and their use in education. There is good reason to suspect that electronic video recordings may eventually outperform in quality of sound and picture and flexibility of use, traditional films and even television systems, at least in situations where distribution problems are minimal.

In Section 7.2.3 on TV we made clear that TV systems have been effectively used to provide information to students. Because the identical interaction of a student with inputs which occurs with TV occurs also with video recordings viewed over television receivers, we can conclude that video recordings can be just as effective as TV in providing information. Perhaps even more so, since no less developed country yet has color TV except Brazil, but color programs can be presented by video tape or disc players.

In an early study at Wayne State University, Tintera found that teachers trained with the aid of video tape recordings rated significantly higher on all teacher performance rating scales than similar groups of trainees who received conventional instruction.[47] It is important to note, though, that in this exploratory study the video tape group did not perform significantly better than a group given the same training with only audio tape recordings.

Later research into what has come to be known as "microteaching" also suggests that video tapes can assist greatly in the training of teachers. Microteaching is real teaching in a practice situation, focusing on the accomplishment of specific instructional skills or techniques. The teacher then discusses his performance with a supervisor, and the students, possibly also playing back a video tape of his performance. He then has an opportunity to repeat the entire process with new groups of students, one or more times.[48]

At Stanford University, where microteaching originated, at Hunter College, and at Brigham Young University, video recordings have been shown to provide a sort of help that hitherto was impossible in indicating to a teacher trainee how he performs. From this he can conclude how to improve his instructional style.[49]

The Stanford findings are representative of these and other experiments. The following conclusions were reached there in 1963, when an experimental group of trainees who received 24 microteaching sessions in 8 weeks were compared with a control group:[50]

(1) Candidates trained through microteaching techniques over an eight-week period and spending less than ten hours a week in training, performed at a higher level of teaching competence than a similar group of candidates receiving separate instruction and theory with an associated teacher aide experience involving a time requirement of between 20 and 25 hours per week.

(2) Performance in the microteaching situation predicted subsequent classroom performance.

(3) Over an eight-week period, there is a significant increase in the accuracy of the candidate's self-perception of his teaching performance through identification of weaknesses as well as strengths.

(4) Candidates who received student appraisal of their effectiveness improved significantly more in their teaching performance than candidates who did not have access to such feedback.

(5) Ratings of video transcriptions of teaching encounters correlate positively with live ratings of the same encounters.

(6) Trainees' acceptance of the value of microteaching is high.

(7) Microstudents' ratings of teaching performance are more stable than any others, including those of supervisors.

While the efficacy of viewing and discussing one's own teaching efforts has been demonstrated, the impact of viewing a modeled teaching situation has not been determined. Allen and Bush developed almost 20 training films for the General Learning Corporation but their effectiveness has not been investigated.

In the last year or so, one after another make of video tape player has appeared, and it is becoming possible to evaluate their engineering effectiveness and the costs of the recorders, players, and cassettes. Player-recorders now retail for about $1,000 and cassettes which run a half hour cost about $25. It is clear that in the next few years competition, mass sales, and new products will bring these costs down, perhaps drastically. Video discs, when they appear, will certainly be competitive in cost with tapes, and quite possibly cheaper. Newsweek, Time, Saturday Review, Barron's National Business and Financial Weekly, the New York Times, and the Gramophone and have all published surveys of this medium.[51] A Saturday Review article by Berger has divided video tape recorders into two classes:[52] "the magnetic-tape systems, which can record, and the more exotic, newer systems, which cannot." Included in the first group are Ampex's Instavision, Arvin's CVR XXI, AVOC's Cartrivision, Norelco's VCR

(Video Cassette Recorder), and Sony's Videocassette. In the second group are CBS's EVR, RCA's Selectavision, and Teldec's Videodisc. In the long run discs will probably be most successful in meeting the needs for low-cost, mass-produced video recordings.

7.2.6 Programmed instruction, including programmed textbooks, teaching machines, and computerized programmed instruction. Programmed instruction is a generic term applied to specially arranged textbooks, materials, machines, and computer-aided or computer-managed instruction which (*a*) requires active responses from a student; (*b*) provides feedback, with minimal delay, about the accuracy of the student's responses; (*c*) controls the aggregating and disaggregating as well as the sequency of information inputs to maximize learning efficiency; and (*d*) permits pacing of learning by the student.[53] Programmed learning is intended to be autoinstructional, *i.e.*, to permit a student to learn specified subject-matters without the assistance of an instructor. Sometimes it can also help the teacher provide a role model, organize the curriculum and classroom activities, evaluate and monitor student performance, give counsel to students and parents, and represent the government to the students. To the extent that programmed learning relieves teachers of some of these responsibilities, it may achieve cost savings. The teachers are then relieved to concentrate more efficiently on those functions that only human beings can carry out.

Naturally programmed learning can also be regarded as a substitute for textbooks or simply as an instructional aid to the teacher (and indeed a teacher or administrator always has ultimate responsibility for it), but less developed countries are particularly concerned with those technologies that can potentially reduce costs of formal and nonformal education. Programmed instruction may not only increase the efficiency of the current teaching staff, but may also make it feasible to use paraprofessionals who have little training in the subject-matter or in teaching. We are particularly interested in the extent to which programmed instruction can alleviate the teacher shortage in less developed countries. Unfortunately the research on such instruction neglects this question.

Programmed instruction has proved a great discovery for the educational researcher. Taber and his associates have said:[54] "The success of programmed instruction depends upon the construction and arrangement of the subject matter material....It is primarily the development of these instructional sequences and their subsequent use in schools that involve the interaction between the science of learning and teaching practice." Unprecedented detailed analysis of the process of student learning has been made possible through the development of programmed instructional materials. The purpose of this research is to increase our understanding of the learning process. Unfortunately, few studies have employed an adequate sample, been conducted over a long enough time period, and dealt with a diversity of subject-matter. Consequently we do not yet have the evidence required to evaluate the ability of programmed instruction to affect educational costs.

The research on programmed instruction has been categorized, in Razik's excellent and exhaustive bibliography, into the following sets:[55]

(a) Characteristics, i.e., research on the mechanics of programmed instruction, such as pacing, step size, or cues; (b) program types, i.e., linear, or branching; (c) type of response, i.e., the behavior requested from the student; (d) subject audience, i.e., different types of student populations; and (e) content subject, i.e., applicability of programmed instruction to different subject-matters.

Below are summarized some of the research findings on the effectiveness of programmed instruction:

"Experimentation conducted thus far supports the expectation that good programs, carefully developed, can significantly improve both the quality and the economy of instruction."[56]

"The comparative methods of machine and nonmachine presentation of printed programs for use in school are as yet an unresolved issue."[57]

"There is little empirical basis at present to favor one general type of program over another."[58]

"More effective teaching machines (i.e., programmed instruction) program sequences result in essentially zero correlation between achievement scores and an I.Q. measure...if students have the minimum ability to master the task then the most efficient sequence will produce a set of learning scores that will not be correlated with I.Q."[59]

Programmed instruction is best developed when the instructional objectives can be neatly expressed in behavioral operational terms. E.g., it is easier to produce programmed instructional materials for mathematics than for poetry writing.

It seems clear that in addition to the lack of research evidence on the effectiveness of large-scale, repetitive use of programmed instruction, there is little evidence about how satisfactorily programmed instruction can fulfill any other teaching functions than providing information and supervision of drill and practice sessions. Much study remains to be done on why programmed instruction seems to work, how well it works and for whom, and how can it work better.[60] These questions seem of secondary concern, however, for less developed countries where the issues of overall feasibility loom largest.

Almost no research has been published on the topics mentioned in the preceding paragraph with particular reference to less developed countries. Many such countries, though, have some persons who, even if untrained to develop programmed instructional materials, are aware of what is involved and have even used such instruction for limited educational purposes with small numbers of students. UNESCO in 1967 published an international directory of resources on programmed instruction throughout the world. Though almost every country in the world is listed as having some resources for programmed instruction, it is apparent that the listing includes institutions and individuals who are simply generally knowledgeable about education rather than particularly expert in programmed instruction. Among the less developed countries, Brazil, Nigeria, India, Southern Rhodesia, Korea, and Taiwan have invested significant resources in experiments and in developing program capabilities.[61] UNESCO in 1967 sponsored two seminars on programmed instruction, one for the Arab states, the other for African states. During the seminars some sample programmed materials were produced by the participants.[62]

As preparation for discussing the costs, and thus the cost-effectiveness, of programmed instruction, it seems desirable to outline briefly the process of writing programmed instruction. The basic steps are:[63]

(*a*) Behavioral objectives are specified in great detail, *i.e.*, what you want a student to be able to do and know at the end of the instruction. (*b*) A course outline is developed to cover and sequence the material necessary to enable the student to attain the behavioral objectives set forth. (*c*) Frames are produced. (Frames is the technical word for the discrete statement, question, or example that the student will be asked to respond to.) (*d*) The frames are edited repeatedly for accuracy of subject-matter and correct sequencing of information, insuring that the student can easily make a correct response to the questions. (*e*) Repeated field testing of the program with students to see if they learn with it and what are the errors they commonly make, followed by revisions of the material revealed as necessary by the field tests.

Naturally the costs associated with these steps cover a wide range, the primary variables being the amounts of time spent on editing and field testing. If one is expecting the programmed instruction to be the primary or sole information source, however, it appears that there is a definite cut-off point in quality below which the programmed instruction will not accomplish its behavioral objectives. There is no good source of information on the costs of developing programmed instruction. It is an iterative technique sometimes requiring few changes and sometimes requiring years of tuning. Two of the biggest producers of programmed instruction in the United States, Sullivan Associates, with Behavioral Research Labs, and the Webster Division of McGraw-Hill, are only able to provide estimates of the costs of their materials. Production of a one-year course for elementary school intended to teach difficult basic conceptual skills for the first time, may cost between $200,000 and $500,000. Such programming requires from 6 to 12 man-years. The price to the consumer for the finished product ranges from $1 to $10 for a single programmed textbook. Obviously they must become available more cheaply or they cannot be afforded by most less developed countries.

The skills involved in creating programmed instruction are those of a curriculum developer with special training that can be accomplished in approximately 6 months. According to De Cecco:[64] "Programming methodology is essentially curriculum planning on a small-scale. In the course of programming it becomes necessary to analyze the subject matter in great detail, and also to analyze the place of the subject matter to the curriculum as a whole. If it does nothing else, the auto-instructional movement performs a valuable service in forcing educators to define what it is they are attempting to teach, or, perhaps, more accurately, what it is they wish their students to learn."

If programmed instruction actually replaces textbooks and other curricular and instructional guide materials, it is somewhat more expensive than traditional means. If it is simply added to on-going curricular efforts it will greatly increase costs unless teachers are used more efficiently. The scarce resource for developing countries will be the personnel to develop the programmed instruction. While more than 1,000 titles of programmed instruction are listed in the United States, there is no complete, coordinated package of materials that could, for example, constitute a complete elementary school curriculum.

Many developing countries are in the process of curriculum revision, trying to adapt their educational system more closely to national needs. They are launching efforts to produce their own textbooks. This process must go on even if programmed instruction were to be used extensively. Less developed countries may need to invest in additional personnel to produce programmed instruction.

Programmed instruction has certain display and format requirements. These can be satisfied in a variety of ways. The selection among these determines both the costs and the educational effectiveness of programmed instruction. The range of display devices extends from a programmed textbook on inexpensive paper with a piece of cardboard for covering the answer column to computer-assisted instruction. The more complicated equipment has the following advantages: It has a variety of possible displays, can prevent a student from "cheating" (*i.e.*, looking at the answers), provides automatic recording of the student's performances for evaluation by teachers, has the capacity for complicated "branching" without paper shuffling by the student, can accept and respond to a range of modalities of student inputs, increased means of student input (i.e., oral, written, typed, or manipulative), and offers potential access to a much larger body of information than can easily be stored in a textbook or even standard library.

Some believe that the advantages of the sophisticated equipment only begin to show instructional benefits that justify cost differences when they involve a computer. The manually and electrically operated noncomputerized teaching machines do not have the flexibility and ease of use, some hold, of even the programmed textbook.

"With respect to the teaching machine of the future," De Cecco predicts, "I see two extremes with little in the middle. At one extreme will be the book formats, scrambled text and programmed text. At the other extreme will be the large-scale computer-based systems with multiple student stations. The more modest, mostly mechanical machines which we see proliferating in today's market will drop out of use in the school."[65]

Computer-aided instruction, which is based on the same educational theories as programmed instruction, but is translated into computer language may one day be broadly applied to educational problems in less developed countries. Already experiments with it are beginning at the Federal University of Rio de Janeiro in Brazil. Telephone networks giving many terminals remote access to large computers or the new powerful and relatively cheap minicomputers may lower costs sufficiently to make this medium fiscally feasible in some of the less developed countries.

There may be one sort of exception to this generalization. A number of extremely inexpensive teaching machines can be operated by a student. These include the audio pointer and plastic hand-held machines using paper tapes that expose only one frame at a time and then the answer after the student selects his answer. The least expensive of these sell for less than $4.

What is known about the effectiveness of programmed instruction? Numerous studies have shown no significant differences when different types of programs, display devices, or subject-matters are compared. Clearly much remains to be learned from basic research on programmed instruction. We need to assess better the potential impact of large-scale use of programmed instruction as a substitute for teachers. It may not be unreasonable, if costs can be cut, to expect that the populations of developing countries which currently have no access to schools could, through independent use of programmed instruction, be adequately prepared for competitive examinations for diplomas or degrees. It would be interesting to know what personality characteristics of learners make them successful in independent, nonproctored use of programmed instruction.

What are the motivational effects on students when programmed instruction is used extensively and repetitively in instruction over a period of years and for extended periods of the day? The research indicates that many learners like programmed instruction but in many of the experiments they use it for only 20 to 30 minutes a day.

Much of the subject-matter of nonformal education in less developed countries involves the learning of manipulative skills. Programmed instruction does not at present seem a good instructional medium for this purpose, so this may limit its use for nonformal education. Dr. Winaro, of the Indonesian Ministry of Education, is however, currently directing a project for creating programmed materials for education on family planning.

Programmed textbooks are as expensive as books and involve the same costly distribution problems in being made available to students throughout a country. Particularly at the elementary level these costs and inefficiencies may seem overwhelming.

Like most other innovations, programmed instruction requires a change in teacher behavior and practices. Once the teacher is released from some of his instructional responsibilities, he becomes a tutor, manager, and curriculum designer. These roles require new types of teacher-training. All the usual problems of changing institutional structures and perceived roles can be expected when programmed instruction is introduced. In some ways programmed instruction is a much more radical instructional innovation than the use of radio or TV. Since programmed textbooks involve no hardware, they may not elicit the resistances that block some educational innovations. On the other hand, they may not elicit the excitement which can help to motivate the teacher-training, educational management, and daily classroom practices that are necessary to maximize the benefits of programmed instruction.

To use most programmed instruction, a student must be able to read. In less developed countries, where the illiteracy rate is high, this limits its utility in elementary school and even more drastically in nonformal and community education. Programmed instruction can be used to teach reading, but not without a fairly large amount of supplementary instruction.

There is no question that the use of instructional radio and television is better understood and more appreciated by educators today than is computer-aided instruction, the most sophisticated form of programmed instruction. Nevertheless, computer-aided instruction has real strengths, as pointed out by Mary Gardiner Jones, a former commissioner of the Federal Trade Commission:[66]

> "The introduction into our educational system of the computer and of the wide variety of associated electronic and mechanical teaching devices, together with entirely new programmed instructional material, presents us for the first time with unique opportunities to deal effectively with many of our educational problems. Use of programmed instructional materials will enable schools to offer a type of individualized instruction geared to the backgrounds and experience of each student. The student can proceed at his own pace and through the branching ability of the computer, the teaching materials can be tailored to the particular difficulty being encountered by individual students. To a certain extent, the student's manipulation of his own computer console can compel him to participate more directly in the educational process and presumably will not enable him to day-dream undetected through entire classes. [Also, as he learns he can create a complete computer record of how far and how fast he went in the process. This record can be substituted for examinations.]

"At the same time, computers and other mechanical teaching devices can consistently exercise a degree of patience, encouragement, and affirmative support for the struggling learners which no teacher has either the time or the saintliness to display at every moment of the day and on every day of the week. [As long as educational institutions have 50-to-1 to 20-to-1 ratios of students to teachers, no teacher member will ever be able to give as much undivided attention to individual students as a computer can.]

"With respect to the sheer acquisition of information and the basic technique of learning, these devices can take over much of the routine drill aspects of teaching and thus free the teacher for those aspects of education which he or she is uniquely capable of doing, namely, to question, to imagine, to invent, to appreciate, to act as a model, a guide, a counselor and fellow-searcher after truth, after values and after meaning and understanding."

Writing on the basis of several years' experience in computer-assisted instruction, Atkinson has reported results from the first year of an experiment using computerized programmed instruction to teach reading to first grade students.[67] He and his associates compared an experimental group with a matched control group. Each group was made up of about 50 first grade students from "culturally disadvantaged" homes, with I.Q.'s averaging 89. The experimental group received their instruction by computer-aided instruction and the control group by traditional classroom teaching. The fastest student taking computer-aided instruction completed over 4,000 more "central" problems during his whole course of study than the slowest student.

This indicates how individualized computer-aided instruction can be. Both groups were tested with conventional instruments before the project began and again near the end of the school year. The two groups were not significantly different at the beginning of the year, but at the end the group receiving computer-aided instruction was significantly better on all of the following posttests: California Achievement Test, Vocabulary Subtest and Total Score; Hartley Reading Test, Form Class Subtest, Vocabulary Subtest, Phonetic Discrimination Subtest, Nonsense Word Pronunciation Test, Word Pronunciation Test, Nonsense Word Recognition Test, and Word Recognition Test. There was no significant difference between the two groups on the California Achievement Test Comprehension Subtest. These findings as a whole constitute an impressive indication of the potential effectiveness of computer-aided instruction.

There is no clear agreement about present or probable future costs of computerized programmed instruction. Atkinson and his colleague, Suppes, at Stanford University have developed computerized materials for learning language skills for grades 4, 5, and 6. They calculate that in a school with 100 terminals which maintained an active program for at least two years, the total cost of using these materials would be about $1.80 per user hour, including all expenses such as terminal rental and royalties.[68] To develop 200 40-minute instructional units cost them about $60,000, or $300 a unit.

Preparation of such instructional units, according to Bacon at the San Jose laboratories of IBM, costs between $500 and $3,000 per student hour, varying greatly with the media, amount of branching, and types of materials.[69] The following uses of computer-aided instruction, he believes, are within practical cost ranges today: (a) For the early grades, simple drills coupled with diagnostic tests showing weaknesses, in such fields as arithmetic and reading. (b) Either before college or earlier, remedial mathematics, grammar, and other subjects. (c) In advanced professional fields, medical diagnosis, business games, computer-aided design, technical simulation, simulation of organizations, and logistic problems.

A study by Kopstein and Seidel compared the costs of traditional classroom instruction with computer-aided instruction in public elementary and secondary schools, higher education, and military technical training.[70] They calculated that, in elementary and secondary education, costs of traditional instruction averaged about 38 cents per student hour in 1971 and will rise to 42 cents by 1974-75. For higher education the cost is greater, having risen from between 37 and 46 cents per student hour in 1949-50 to between 82 cents and $1.02 per student hour in 1963-64, the last date for reliable data. In military and technical training they believe that $1.80 may be about the average cost per student hour. Making a certain number of assumptions, they calculated that the total costs of computer-aided instruction at present amount to $3.73 per student hour and concluded that unless this medium can be shown to be at least ten times more effective than traditionally administered instruction, a replacement does not now appear to be justified. They believe, however, that with further developments which seem likely to occur in the field of computer-assisted instruction, a forecast of costs of 11 cents per student hour for computer-assisted instruction seemed probable in a few years.

According to Zinn, costs for computer-aided instruction are reported by various workers as ranging between $2 and $15 per user hour, although one project claims it has achieved a cost of only 27 cents per user hour at consoles which include a keyboard, graphic display, and image projector.[71]

A Booz, Allen, and Hamilton consultant group which studied the costs of instructional television and of computer-assisted instruction for the Committee for Economic Development concluded that the costs of the latter are relatively much higher.[72] They calculated that for a 100,000-student school system the annual rental cost for present hardware needed for one student hour a day of drill-and-practice computer-aided instruction would be $20 million; $6 million would be required for other services; and about $765,000 would be consumed annually for software, making a total of about $27 million for a 100,000-student system, or about $1.35 per user hour. If a more complex tutorial mode of operating computer-aided instruction were employed, they calculated that one hour of software would cost about $30,000 to produce. (This cost is much higher than the cost of some such software now being produced.) For one hour of such instruction daily in a school system of 100,000, the annual software cost would, therefore, be about $5 million, hardware rental about $50 million, and other services about $17 million, for a total of about $72 million, or about $3.70 per user hour. It seemed to this group that at an annual cost in this range the large-scale use of computer-assisted instruction is at present too expensive when possible benefits are considered, but they believed that probably such costs will come down in the not-too-distant future and recommended research to decrease them. Sharing programs among school systems is obviously one way to do this.

## CHAPTER III

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# CHAPTER IV

## A Research Map

### 1. Two Examples of Systems Analyses of Educational Systems

Increasingly leading educators in many nations of the world are approaching their professional problems by using systems analysis. Educators often use the phrases "systems approach" and "systems concepts," even though some of them may not be exactly clear what they mean by the terms. Certainly one expert employs these words quite differently from another expert. Some have quite explicitly used systems analysis in conceptualizing educational systems and the use of instructional technology in them. Two recent examples appear in books which we mentioned in Chapter III above and which are currently having important impacts in education generally and in instructional technology particularly, in the United States, in other established nations, and in less developed countries. One of these is Bretz's book entitled A Taxonomy of Communication Media.[1] The other is Coombs's book The World Educational Crisis: A Systems Analysis.[2]

Both these authors view an educational system as a living system--to use Coombs's phrase "with interacting parts that produce their own indicators as to whether the interaction is going well or badly."[3] They both also recognize, explicitly or implicitly, that there are inputs and outputs to instructional systems. These include various forms of matter and energy, both living persons and nonliving "physical items" such as are needed for construction and maintenance of school buildings and as instructional technology hardware. There are also, both agree, inputs and outputs of information. Moreover, inside the system, matter-energy and information flow through various subsystems and components.

### 1.1 The conceptual system of Bretz.

The model of the instructional process which Bretz presents is diagrammed in Figure 4. Using his diagram he describes the instructional system as follows:[4]

"The large block labeled 'Information' represents the recorded information of the world. The input to this vast data bank is shown at the bottom, where reality is observed and becomes known facts--hence data. The librarian, knowing the needs of various kinds of users, works within this area, creating and maintaining order. All recorded information and all of the order it may possess exists ostensibly for one reason: so that this information may be imported to others....

"Information is...retrieved by the instructor, shown at the lower right [of Figure 4], whose purpose is to build it into instruction. Most of this information enters his knowledge [stored in his memory], where it is combined with existing knowledge acquired from experience or earlier training. Out of this combined knowledge a selection of information is made, organized and encoded as an instructional message. Some of the information which the instructor retrieves, however, may not actually

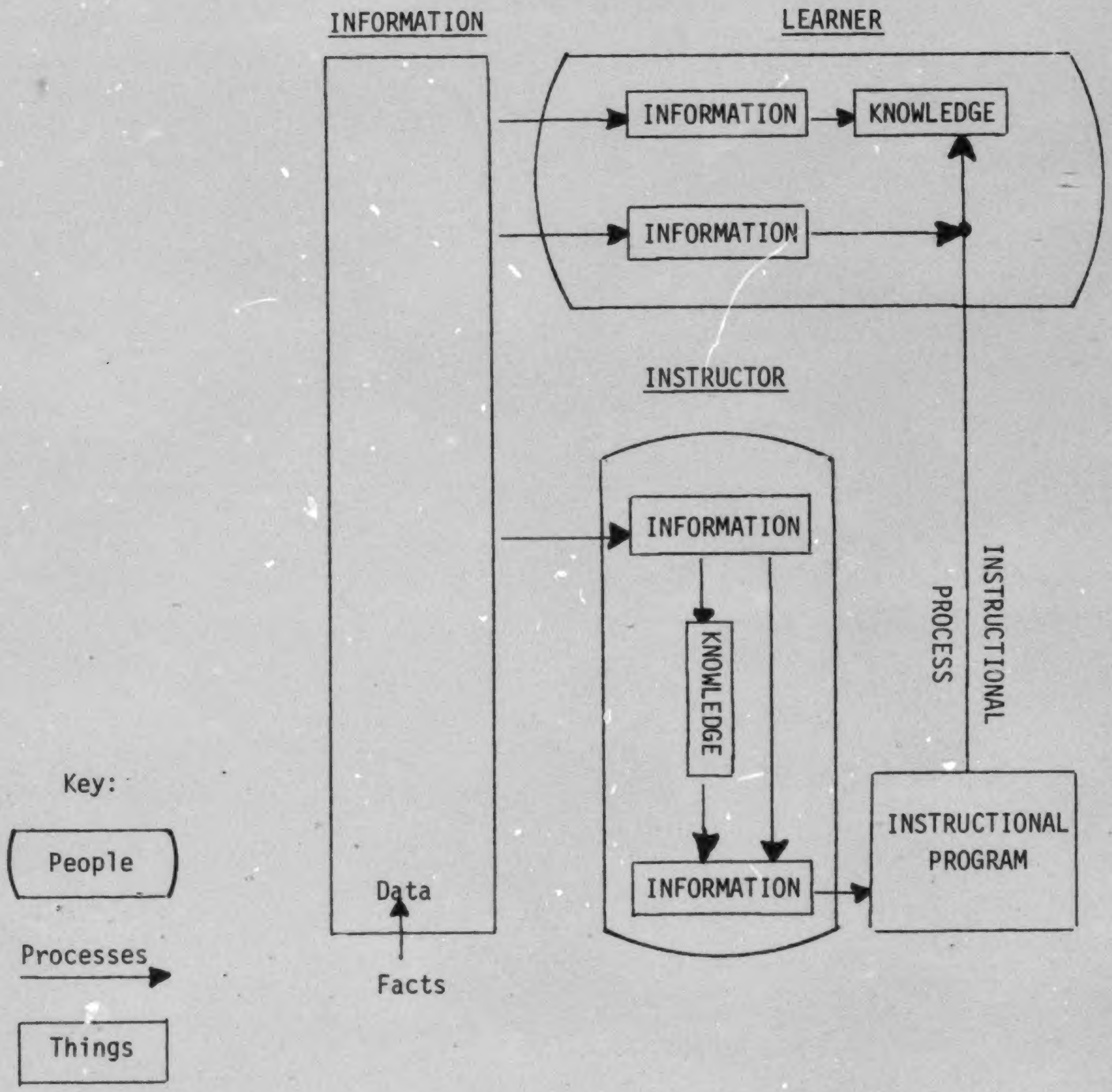
INFORMATION
LEARNER
INFORMATION
KNOWLEDGE
INFORMATION
INSTRUCTOR
INFORMATION
KNOWLEDGE
INFORMATION
INSTRUCTIONAL PROCESS
INSTRUCTIONAL PROGRAM
Data
Facts
Key:
People
Processes
Things

Figure 4. Conceptual Model of Information and Instruction Relationships.

(Adapted from R. Bretz. A taxonomy of communication media. Englewood, N.J.: Educational Technology Publications, 1971, 14.)

go into his knowledge bank at all, but may be used directly in his instructional task. (This is represented by the arrow bypassing the instructor's knowledge.) The amount of information taking this route will vary inversely with the creativity of the instructor.

"That part of the instructional process which contains information--the lesson--is labeled 'Instructional Program' in Figure 4. The reason is this: the term 'instructional program', originating in the vocabulary of programmed instruction, implies considerably more than the presentation of information; it also includes the direction of learner activities relevant to the information, the provision of resources, and the application of methods for the practice of responses until the achievement of stated learning objectives can be certified. Thus it may encompass some, much, or all of the instructional process. The program may actually direct the entire process, then, rather than simply initiate it, as the lesson commonly does.

"As stated above, one of the most important objectives of instruction, especially in terms of lifelong education, is to train the learner to utilize the information bank directly and to devise his own instructional process. This skill should be called self-instruction or independent study rather than self-study, since with it, the learner directs his own activities. 'Self-study' describes any learning activity of any sort which is performed individually, even if it is no more than rote memorization. Self-instruction, on the other hand, incorporates heuristic methods such as inquiry and search-and-discovery. The lower arrow from the information bank to the learner represents the activities involved in learning self-instructional skills. The upper arrow represents this same process taking place outside the instructional process after transfer of the learned heuristic skills, so to speak, into daily life."

### 1.2 The conceptual system of Coombs.

The model of Coombs is somewhat similar to the above model, but there are very important differences. He describes his approach using Figures 5 and 6. Asserting that it is a systems analysis of an educational system, he goes on to say, very cogently:[5]

"In contrast to the meaning which the phrase 'systems analysis' has in some other contexts, it should at once be stressed that its use does not entail the mathematical expression and measurement of all that is involved. Rather, it functions as a wide-angled lens trained on an organism so that it can be seen in its entirety, including the relationships among its parts and between the organism and its environment.

"A 'systems analysis' of education resembles, in some respects, what a doctor does when he examines the most complicated and awe-inspiring 'system' of all--a human being. It is never possible, nor is it necessary, for the doctor to have complete knowledge of every detail of a human being's system and its functional processes. The strategy of the diagnosis is to concentrate upon selected critical indicators and relationships within the system and between the system and its environment. The doctor, for example, is concerned especially with correlations between such critical indicators, as heartbeat, blood pressure, weight, height, age, diet, sleeping

→ EDUCATIONAL PROCESS →

Resource INPUTS →

1. Aims and priorities
   to guide the system's activities
2. Students
   whose learning is the main aim of the system
3. Management
   to coordinate, direct, evaluate the system
4. Structure and time schedule
   to deploy time and student flows among different purposes
5. Content
   the essence of what students are intended to acquire
6. Teachers
   to help provide the essence and orchestrate the learning process
7. Learning aids
   books, blackboard, maps, films, laboratories, etc.
8. Facilities
   to house the process
9. Technology
   all the techniques used in doing the system's work
10. Quality controls
    admission rules, marks, examinations, standards
11. Research
    to improve knowledge and the system's performance
12. Costs
    indicators of efficiency of the system

→ Educational OUTPUTS

Figure 5. The Major Components of an Educational System.

(From P.H. Coombs. The world educational crisis: a systems analysis. New York: Oxford University Press, 1968, 11.)

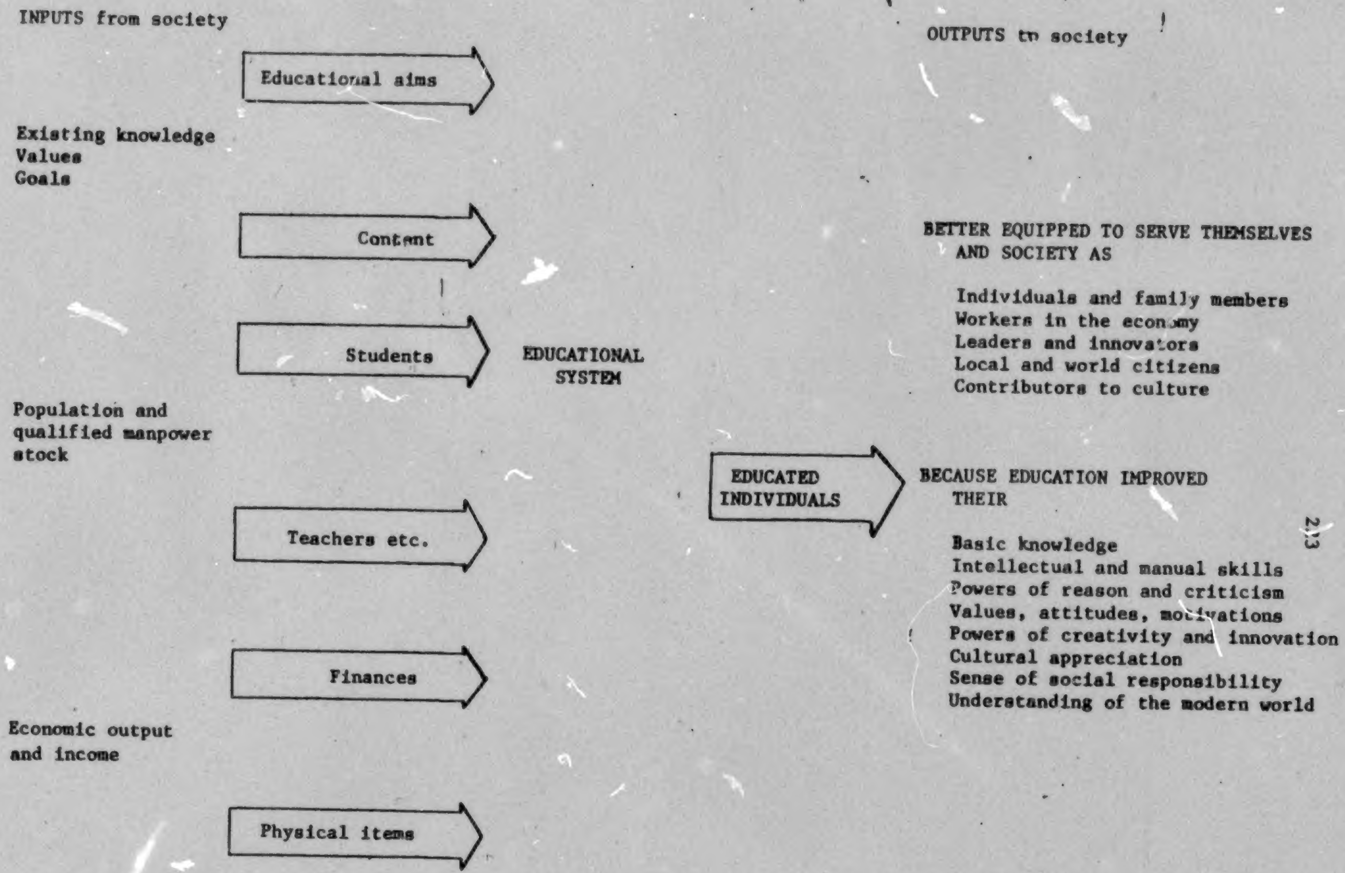
INPUTS from society
Existing knowledge
Values
Goals
Population and
qualified manpower
stock
Economic output
and income
Educational aims
Content
Students
Teachers etc.
Finances
Physical items
EDUCATIONAL SYSTEM
EDUCATED INDIVIDUALS
OUTPUTS to society
BETTER EQUIPPED TO SERVE THEMSELVES AND SOCIETY AS
Individuals and family members
Workers in the economy
Leaders and innovators
Local and world citizens
Contributors to culture
BECAUSE EDUCATION IMPROVED THEIR
Basic knowledge
Intellectual and manual skills
Powers of reason and criticism
Values, attitudes, motivations
Powers of creativity and innovation
Cultural appreciation
Sense of social responsibility
Understanding of the modern world

Figure 6. Interactions Between an Educational System and Its Environment.

(From P.H. Coombs. The world educational crisis: a systems analysis. New York: Oxford University Press, 1968, 12.)

habits, urinary sugar content, white and red corpuscles. From these he appraises the way the total system is functioning, and prescribes what may be needed to make it function better.

"What the doctor does in his analysis of the human body, modern management does in its 'systems analysis' approach to the operations and plans of everything from department stores to military establishments. The 'indicators' differ from context to context, but the strategy remains much the same. By extension, this is also true of a systems analysis applied to an educational system...

"In our use of the phrase 'educational system' we mean not merely the several levels and types of formal education (primary and secondary, post-secondary, general, and specialized), but also all those systematic programs and processes of education and training that lie outside 'formal' education. These, called nonformal education, include, for example, worker and farmer training, functional literacy training, on-the-job and in-service training, university extension (extramural), professional refresher courses, and special youth programs. The formal and nonformal educational activities collectively comprise the nation's total organized educational efforts, irrespective of how such activities may be financed or administered.

"Even beyond these wide limits, of course, there are a myriad of other matters which, in any broad view of learning, are educative in nature, often profoundly so. They include things that are often taken as much for granted as the air we breathe--books, newspapers, and magazines; movies, radio, and television broadcasts; and above all the learning that goes on daily in every home. For the present, however, we must confine our view to those activities which are consciously organized for the express purpose of achieving certain prescribed educational and training objectives.

"An educational system, as a system, obviously differs greatly from the human body--or from a department store--in what it does, how it does it, and the reasons why. Yet in common with all other productive undertakings, it has a set of inputs, which are subject to a process, designed to attain certain outputs, which are intended to satisfy the system's objectives. These form a dynamic, organic whole. And if one is to assess the health of an educational system in order to improve its performance and to plan its future intelligently, the relationship between its critical components must be examined in a unified vision.

"This, however, is not the way we customarily view an educational system. We call it a system but we do not treat it as one. The school board meets to deal item by item with a laundry list of things. Each item is taken up and examined seriatim on its own terms. The daily calendar of the overworked school administrator is typically a similar melange of 'items to handle.' He moves as expeditiously as he can from one to the next, having little time to reflect on how they impinge on each other, or on yesterday's and tomorrow's calendar of things."

He then refers to Figure 5 which lists some important internal components of an educational system and then goes on to give two examples of how they interact with each other:[6]

"Let us assume that a decision is made to alter the system's aims or priorities in some fashion--for example, a decision to diversify secondary education, to include a new technical track to higher education and new 'terminal' programs with a vocational bias. To implement this decision may require far-reaching changes in the system's academic structure in the curriculum and teaching methods, in facilities and equipment, and in the distribution of teachers and the flow of students within the structure. In short, virtually every component is substantially affected by such a change.

"Similarly, without any change of basic aims or priorities, a significant innovation in the curriculum, such as the adoption of 'new mathematics' in place of traditional mathematics, may entail substantial alterations in teaching and learning methods, which in turn may require changes in the deployment of time, in physical facilities and equipment, and in the number and kind of teachers required. This chain reaction may thus have considerable consequences for the system's input requirements and for the quantity and quality of its final outputs.

"[Figure 5], however, does not show the whole of what must be looked at in a systems analysis. The [figure] is confined to the internal components of the system, detached from the environment. Yet since it is society which supplies the educational system with the means of functioning--just as the educational system in turn is expected to make vital contributions to society--something more must be added to the picture of systems analysis. Education's inputs and outputs must be examined in their external relationships with society, for these reveal both the resource constraints that limit the system and the factors that ultimately determine its productivity to society. Hence [Figure 6 ] shows the multiple components of the inputs from society into the educational system, followed by the multiple outputs from that system which flow back into society, upon which they ultimately have many diverse impacts.

"To illustrate how things interact, suppose that an educational system is called upon to produce more scientists and technologists. For this it needs more specialized teachers, but they are in scarce supply because they are being underproduced by the system, relative to market demand. To raise its production, education must get back from its own limited output of such people enough of them to serve as inputs. But to this end its offers to such qualified personnel must be able to meet the market competition from other users. This may require a considerable change in its teacher-salary policies and structure.

"[Figures 5 and 6 ] raise many questions....They include such matters as the meaning of 'management,' the nature of educational 'technology,' the meaning of 'efficiency' and 'quality,' and doubts about the reliability of resource inputs as indicators of the quality of educational outputs. They include the need to define the difference between the internal and external ways of judging the quality and productivity of an educational system's performance, and to suggest how these different angles of vision can lead to different judgments. They also include the need to identify key and reliable indicators of an educational system's performance on both the input and output side.

"[It] is in point here to establish a clearer relationship between the two [figures]--the first dealing with the internal aspects of an educational system, and the second with its external linkages. The relationship can be put in a capsule by postulating the following: First, if external conditions lead to changes in the inputs available to the system--as when a national manpower shortage and an unfavorable salary structure result in a shortage of teachers--the effect within the system may be a decline in the size and quality of its outputs. On the other hand, the input stringency may conceivably provoke a change in 'technology' and in the use of resources calculated to avert a decline in the size and quality of the outputs. The systems analysis thus shows that there need be no rigid pattern of internal responses to which an educational system must adhere in meeting external stringencies. Aided by such an analysis, the system is in a position to choose its own response, and the choice it actually makes can have a considerable influence on the quantity and quality of its output, and on its internal efficiency and external productivity."

It is characteristic of the present early stage of systems theory in the behavioral sciences that even though Bretz and Coombs are both clearly attempting to use systems approaches to the study of educational systems and the instructional process, and even though they have certain similarities in their two conceptual systems, the components within their systems are significantly different. Bretz is quite accurate and insightful in distinguishing in his conceptual model between living matter-energy inputs (people) and nonliving matter-energy inputs, throughputs, and outputs (things). He also makes the important distinction between structures and processes. His analysis of the structure and process of an educational system, however, is brief and superficial, which perhaps is all he thought necessary for the purposes of his book.

The conceptual approach of Coombs is more detailed, but his analysis of the resource inputs, the educational process, and the educational outputs leaves much to be desired. A particularly serious problem is the fact that he combines different sorts of concepts under the rubric of "the major components of an educational system" in Figure 5. It would have been better if, as Bretz and we do (see pages 40 to 50), he had distinguished between two major sorts of matter-energy, living (e.g., people) and nonliving (e.g., things or artifacts), as well as two major sorts of information, linguistic messages and money.

These two conceptual systems of experts respected in the educational community bring forceably to our attention the urgent need for systems scientists today to come to general agreement as to what are the components or subsystems of living systems. Referring back to our conceptual approach to living systems in Chapter I we would like to point out how we would deal with Coomb's list of major components of an educational system. If one is to have clear understanding of the internal structure and processes of such a system, one must not lump together under a term like "components" concepts which are very different in character, as Coombs does. It is not, of course, likely that as thoughtful a scholar as he even believed that components [see Figure 5] such as aims and priorities, management, structure and time schedule, content, learning aids, technology, research, and costs were comparable concepts. Yet Coombs does not clearly spell out how he conceives these structures, processes, dimensions, and abstract principles to interact in educational systems. It seems essential to specify this. Nevertheless, we must recognize that he has created a perceptive list of the major aspects which must be included in an overall systems approach to the analysis of an educational system.

The parallels presented below indicate how our theory of living systems would deal with each of Coomb's concepts:

| Coombs's Components | Our Equivalents |
|---|---|
| 1. Aims and priorities, to guide the system's activities. | 1. Information about purposes and goals of the system (see page 49) set by the decider subsystem and usually transmitted throughout the system over its channel and net subsystem. |
| 2. Students, whose learning is the main aim of the system. | 2. Students, who are living inclusions (see pages 40 and 41) receiving services from the system. |
| 3. Management, to coordinate, direct, and evaluate the system. | 3. The decider subsystem (see page 39), either centralized or decentralized, and the decider subsubsystems of all matter-energy and information processing subsystems. |

| Coombs's Components | Our Equivalents |
|---|---|
| 4. Structure and time schedule, to deploy time and student flows among different purposes. | 4. It is unclear whether "structure" to Coombs means the same as to us, the arrangement of the system's subsystems and components in three-dimensional space at a given moment of time or whether he also includes in the term the hierarchical conceptual arrangement of the system's components, i.e., its table of organization. "Time schedule" represents the output of information from a component of the decider, either centralized or decentralized, which issues a directive to persons in the system as to what actions they shall take at specified moments on the time dimension. Of course, everyone does not always comply with this time schedule. |
| 5. Content, the essence of what students are intended to acquire. | 5. The subject-matter or content which the students are expected to learn represents first of all an information input to the system over its input transducer and then a transmission over various other information processing subsystems. At times it may be stored in the memory subsystem but ultimately it is learned or partially learned by students in the associator subsystem. Finally some of this information leaves the subsystem with the students when they graduate, which is a process of the output transducer subsystem. |

| Coomb's Components | Our Equivalents |
|---|---|
| 6. Teachers, to help provide the essence and orchestrate the learning process. | 6. Teachers are human organisms who are subcomponents of the associator subsystem primarily, but they may also carry out some processes of other subsystems, particularly the information processing subsystems. |
| 7. Learning aids, books, blackboards, maps, films, laboratories, etc. | 7. These instructional media are nonliving artifacts of matter-energy which enter the system through the ingestor of the input transducer and at the time of their entrance are, or later become, markers bearing information. They flow through the educational system or are stored in it. |
| 8. Facilities, to house the process. | 8. Facilities, such as the school building or other structures and the furniture in them, along with the people who maintain them, essentially are the supporter subsystem. |
| 9. Technology, all the techniques used in doing the system's work. | 9. This is an abstraction representing all the processes, learned and unlearned, which go on in the system. It is so general as to be relatively useless. If an analysis of system processes were to be at all precise or useful, it would have to break them down into the multiple categories of matter-energy and information processing activities of the various subsystems and components. |
| 10. Quality controls, admission rules, marks, examinations, standards. | 10. These represent information produced by processes in the decider subsystem, whether it be centralized or decentralized. Some of this information is conveyed as feedbacks from parts of subsystems and determine the nature of the system's inputs, internal processes, and outputs. To describe these information flows adequately it |

| Coomb's Components | Our Equivalents (10 cont.) |
|---|---|
| | would be necessary to say between which components of which subsystems they occur and how much power or control such signals exert upon particular subsystem processes. |
| 11. Research, to improve knowledge and the system's performance. | 11. Research on the system's environment begins with collection of information through the input transducer, and research on the system itself begins with collection of information through the internal transducer. These inputs are then transmitted through the channel and net subsystem and other information processing subsystems to a component of the decider that actually carries out the research analysis and makes conclusions from them. These conclusions represent decisions that may or may not control system activities in the future. Sometimes in this process the memory subsystem may be consulted for information relevant to these research analyses. |
| 12. Costs, indicators of efficiency of the system. | 12. Costs are not really indicators of the efficiency of the system, but rather constitute the numerator of a cost-effectiveness ratio. Costs can be measured as the amount consumed of matter, energy, information, money (a type of information), or time. It is important that independent measures of effectiveness be made and that the external effectiveness or internal efficiency of a system be determined by looking at indices of both costs and effectiveness, rather than of costs alone. |

The aspects of educational systems on which Coombs concentrates his attention are well selected, but his analysis of their interrelationships is so simple that it is confused. One reason for this is that in his list of system components he does not make important distinctions, as between:

- Systems (like students, management, or teachers) versus dimensional characteristics of systems (like their structure in space or time schedules)
- Concrete systems in space-time (like people, classes of students, and books) versus abstractions (like a time schedule or curricular content)
- Structures (like facilities) versus processes (like technology, which Coombs defines as "all the techniques used in doing the system's work," or research)
- Matter-energy (like teachers, learning aids, or facilities) versus information (like aims and priorities, content, or monetary costs)
- One level of living systems such as organisms (like teachers or students) versus another level of living systems such as groups (like management)
- One type of systems such as living persons or groups (like students or management) versus another type of systems such as nonliving objects (like learning aids or facilities)
- One sort of flow such as linguistic information (like instructional content) versus another sort of flow such as monetary information (like costs)
- Parts of systems (like management or teachers) versus inclusions in systems (like students)

Incorporating such distinctions makes conceptualizations more complex but it also makes them much clearer: Any theoretical view which lumps systems with their dimensions is confusing. If a concrete system which observers can locate in space-time is classed with an abstraction, one faces the cognitive challenge of multiplying apples and oranges. If a structure enduring in space, such as an educational facility like a school building, is classed with a process, such as research which continually changes over time, one is puzzled. Unless matter-energy and information are distinguished, one cannot follow the separate sorts of flows which constitute a system's processes.

Parsimony is desirable, but useful analyses of educational systems must be complex enough to make basic distinctions like those discussed above. The research map which we are about to present in this chapter incorporates such distinctions.

1.3 Some of the primary components in Coombs's conceptual approach. Before we turn to the research map it will be worth our while to devote a little attention to the eight aspects of educational systems which Coombs lists first in Figure 5. Though these aspects are not comparable concepts, he has selected important ones for special attention.

1.3.1 Aims and priorities. Most teachers, schools, or school systems are vague about their educational aims and priorities. They would find it hard to make them explicit and they rarely are required to. But it is difficult to plan rational curricula without knowing specific objectives. It is equally hard to do a good job of teaching, preparing instructional materials, writing examinations, or evaluating the effectiveness of a training program. Coombs undoubtedly listed aims and priorities first because logically they come first. Unfortunately, however, they are usually formulated well after an educational system is in operation, if ever.

1.3.2 Students. Of course students are the reason why an educational system exists, the consumers of its services. Even though some high school and college students in recent years have wanted to have votes as "part of the system," they were not exactly right. They perhaps deserved to vote in order to provide feedbacks from consumers, which can make any system give more responsive services, but they are living inclusions (see pages 40 and 41) not part of the system. When they are admitted or when they graduate, they are inputs or outputs--the system's structure is unchanged.

The most important consideration about students in less developed countries, from the viewpoint of educational planning, is that the average rate of their educational advancement is disturbingly slower than that of students in established nations. Their parents have had much less education, and are often illiterate, the tradition of education does not exist in the family, the promise of jobs is uncertain, they are needed to help at home, and consequently, their motivation to study is low. The result is that the students commonly drop out of school very early and the number who complete even the primary grade is low. Bringing the traditional pattern of educational achievement in the less developed countries closer to that in established nations is the chief challenge to educators in those lands.

1.3.3 Management. This is the decider subsystem which carries out all administrative functions of the educational system. Administrative personnel include all personnel who are responsible for decision making, forecasting, problem identification and resolution, supervision, training, staff and fiscal management, evaluation, and counseling of instructors and other staff. In less developed countries the efficient performance of these activities is commonly hampered by the same pathologies found in most bureaucracies: vested interests in the status quo which resist change of any sort; insufficient delegation of authority to the subordinates who are expected to make certain sorts of decisions, leading to frustration and poor motivation of such subordinates; a lack of adequate training of some personnel in both education and management; a lack of professionals qualified to conduct educational research, planning, forecasting, or evaluation; and inefficient teacher-administrator ratios, with too few (rarely too many) managers for the number of teachers.

These problems are extreme in some countries and are often expected to be overcome despite a great lack of resources. The deciders of most educational systems of less developed countries are centralized for the purpose of tying education to national development. This has often led to a hierarchy of command in the larger countries that is almost unworkable, particularly with the poor communication facilities that exist. The information of directives from higher echelons often does not get adequately transmitted over the channel and net subsystem to the operational units, or is transmitted in distorted form. Feedback from lower to higher echelons is similarly inadequate or nonexistent. In addition, the meager wages paid to civil servants compound the problems of bureaucratic lethargy. For example, the rural primary school supervisor may not be able to afford the fare for whatever form of transportation is available and spend the many hours required traveling to visit the schools under his jurisdiction. Finally, the people who come to be the educational managers often lack the necessary expertise to perform effectively. The supervisors frequently have no more training than the teachers they are supposed to supervise, while the more responsible educational officers often have not been trained in the simplest elements of budget preparation, staff selection, and management. This situation leaves the observer with two major conclusions: (a) educational administration in less developed countries has rarely led to organizational structures with adjustment processes capable of coping with the specific problems of these countries; and (b) communication up and down the echelons of the administrative hierarchy is often extremely slow, cumbersome, and nonproductive.

1.3.4 Structure and time schedule. Coombs, as we have noted, says that these "deploy time and student flows among different purposes." The structural organization of any educational system obviously influences its day-to-day operations. If it is highly centralized, decisions are coordinated but they often do not adapt to local problems, sometimes they are slow in coming, and at times they are never made at all. If it is highly decentralized and communications are poor, the system may respond to local needs but suffer from poor coordination. Time schedules have various influences on educational processes. They determine the number of hours a day the student spends in formal education--which differs markedly from nation to nation and culture to culture. They determine how many months a year and in what months the student attends school--which often in agricultural areas is adjusted so that children can help their parents with the harvest. They determine how long class sessions shall be and how frequently a certain subject-matter is discussed--which are factors in efficiency of learning. They determine how hard a teacher must work--which influences his morale. All these matters have impact on system effectiveness.

1.3.5 Content. What shall be the main courses in a curriculum and their proper sequence? What shall be the chief topics studied in each course? How much of the subject-matter shall be organized by the teacher or someone else before presentation to the student and how much left to him to organize? All these questions have traditionally been basic concerns in educational systems. In recent years other issues about content have arisen. They have dealt with the proper content to accomplish the system's aims and priorities and have been summarized in the question: "Is it relevant?" In many less developed countries the traditions and prestige of the educational systems of the established nations with which they have been related have caused the former to imitate the curricular content of the latter. This often has been highly academic and impractical, poor preparation for life in the established country and even worse for the more primitive existence in the less developed country. Recent educational reforms in several of the latter nations have centered on change of curricula to relate better to the realities of life in them. They have also shifted from content only vaguely related to unexpressed educational objectives to content clearly directed toward explicit educational goals. The emphasis has changed from the learning of many facts to the learning of how to cope with and solve problems. And finally the approach of the teacher has altered in some countries away from a didactic and harshly authoritarian approach to one directed toward greater personal support for the student in order to motivate him to enjoy learning and to feel confident in his ability to solve his own problems.

1.3.6 Teachers. Teachers primarily act as professionals to direct the learning of students, and as such function primarily in the educational system's associator subsystem (see page 39). But they have other functions as well, more diverse and important functional responsibilities than any other actors in the formal or nonformal educational system, except the students. In many they are the most (often the only) significant influences on the students. In school systems everywhere, teachers' salaries constitute the single greatest cost of an educational system, 90 percent of the budget in many cases. Traditional forms of education are highly labor-intensive. It is, therefore, critical that teaching functions be performed effectively and efficiently. Unfortunately, at present in many lands this appears not to be the case.

In less developed countries now, student-teacher ratios in primary schools are near 50 to 1. And in the traditional form of education in these systems there is no adequate means for overcoming the resultant neglect of individual pupils. At higher levels of schooling the situation is somewhat better. In Kenya, for instance, enrollment in governmental secondary schools is set at 35 per class while most schools have a few more teachers than classes, resulting in ratios which are probably a bit lower than 35 to 1. In adult education programs the instructor-student ratio is as low as in the primary school, and the capability of the teachers is worse. This, however, tells only half the story. Beeby has poignantly and accurately pointed out the discrepancy between the existing educational level and training of teachers in the less developed countries and the critical role they play in education.[7]

Teacher quality has been improved at higher levels of education in some countries by using aliens to teach. Almost all vocational education teachers, for example, may be foreign. Nowhere has this been more true than in Africa, where European and American teachers often account for more than 50 percent of the secondary school teaching force. Such a policy may severely limit the development of a sense of indigenous national unity.

Outside the formal school system the situation is not much better. In the subject areas of health and agriculture, the responsibility for education is usually shared between the Ministries of Education and Agriculture, with insufficient personnel commonly being devoted to programs, as each ministry leaves the ultimate responsibility to the other one. At the same time literacy programs suffer because the personnel are too few and too poorly trained to teach reading and writing and also follow up this training with continued help in procuring functional reading material. A recent doctoral dissertation at Harvard's Center for Studies in Education and Development reviewed a wide range of literacy programs and found that none had really been successful, and that one program in Africa was staffed by instructors over half of whom could not read themselves. It appears, however, that this conclusion may be too gloomy. All reports indicate that in recent years at least one literacy program, MOBRAL, which relies on massive use of instructional technologies, has had major impact in decreasing illiteracy in Brazil.

1.3.7 Learning aids. The traditional artifacts or equipment used in education--blackboards, textbooks, and audiovisual aids--have come to be status symbols in some less developed countries which show undue respect for the material accouterments of educational activity. The almost complete lack of any learning aids except crude blackboards in many less developed countries harks back to the still widely held belief of the ancient Greeks that education is essentially a person-to-person dialogue.

Since the invention of the printing press the most important nonhuman input into education has been the textbook. However, in certain less developed countries over the years fewer and fewer of them have been used. As the number of students has increased the costs of textbooks have become more than the country can afford. One index of how good and how available the traditional educational inputs are in a country may be obtained by examining the stage at which that country is in its use of textbooks. The best way to assure adequate supplies of texts would probably be for the government to provide all books for all students free of charge. A financially pressed government begins to retreat from such a policy as pinched budgets force it to eliminate some books. Others are provided to the pupils "at cost." When the budgetary crisis is worst, all books have to be bought by the students. Indonesia is an excellent example of such complete lack of textbooks provided by the government. The teachers there commonly report that their students buy their own texts. A visitor is hard pressed, however, to see any evidence of this. In fact even the teacher may not have a textbook. The best he can afford to do is write his old school notes on the blackboard for his students to copy.

Indonesia also reveals other problems associated with providing printed matter for all kinds of education: a severe paper shortage, insufficient numbers of good writers of the Indonesian language, a disorganized printing industry, poor distribution methods, and--if a book ever reaches a school--low motivation of both teachers and students to use it. Such problems, amply documented in a 1967 AID report, are found in varying degrees of severity in all less developed countries.[8] In some countries--Afganistan for instance--no textbooks are published.

A salient problem for anyone interested in modern instructional technologies, which directly affects whether and how equipment will function, is the state of the public utilities that supply schools and educational centers. Most important are the availability and adequacy of electric power. In most less developed countries few rural schools (and this means the bulk of the primary schools) have electricity. Even where they do, in countries as diverse as Zaire and the Philippines, the service is often not dependable. Also telephone service is often absent, radio is programmed only for entertainment and not at all for instruction, and there is no TV. Under such circumstances obviously most local educational activities are isolated. In many countries even postal service is so faulty that it precludes effective administrative communication. These shortcomings indicate the great need in such nations for technological innovations that can cheaply make communication and diversification of educational inputs possible.

Innovations in learning aids have been attempted in some countries. Iran, for instance, publishes a small school magazine which is eagerly purchased by most students in the later years of primary school. Kenya has a well prepared educational radio schedule, complete with a teacher's guide and attractive schedules that can be posted on bulletin boards. And the student-centered mathematics and science programs developed by the Educational Development Center are finding wider and wider acceptance throughout Africa, bringing with them the increased development of student- and teacher-prepared classroom materials.

A shortage or complete absence of learning aids severely handicaps most programs of adult and vocational education in many less developed countries.

1.3.8 Facilities. Most educational activities are housed in some building. The facility not only shelters such activities but also, in many communities, becomes a status symbol and occasionally is the center of community social life. The building gives a solidity to education, being a concrete representation of the established policy to continue it permanently. This obviously makes parents and educational administrators more secure.

Typically a rural primary school or community education center in most of the world is extremely short of resources. Often made of mud with only half partitions between rooms and a thin tin roof, these schools and centers do not provide an auspicious setting for learning. In fact, the noise of rain in the tropics may make teacher-student interaction impossible even if they have been able to get to school through the rain. Into such inadequate quarters are squeezed as many children as there are in the community. This may mean three of four pupils at a two-person desk and very high student-teacher ratios.

After finishing primary school, if he does not drop out, the rural child is faced with a secondary school that, if it accepts him, is often miles away. Even an urban child, after passing his final elementary school examination, may lose out in his bid for a seat in a local public school and have to travel miles to find a private school that will take him. Schools are generally deficient in library resources and laboratory space. If it is a boarding school, as in much of Africa, the quarters are cramped and there is little privacy. There are just not enough buildings for the number of students that both the government and the people would like to have educated and are trying to accommodate. Even if the learner does not go away to secondary school, there is no facility nearby for pursuing an out-of-school education.

In institutions of higher learning the secondary school facility problems are compounded by the increased resources demanded for more advanced scholarship. Libraries are small or nonexistent, dormitories may be nothing more than barracks, and laboratories usually exist but they may occupy what is really a classroom. Nonformal and adult education are commonly carried out in schools or other community buildings, but often lack of shelter keeps sessions from being held during the rainy season.

## 2. The Table of 26 Research Projects

In selecting research projects for the research map and determining their priorities, we employed the conceptual approach to the study of living systems outlined in Chapters I and II. We recognized, first of all, that we were concerned in each project with the educational or associator subsystem of a nation, ordinarily a less developed country. We viewed this subsystem as being a system in its own right, composed of various lower levels of living systems.

We recognized also that formal educational programs are only a part of the total associator subsystem, and that the entire subsystem must be considered, including the nonformal components which are often neglected although they are usually or always more important to the total learning activities of a community or country. These provide education to persons of all ages in such areas as health, nutrition, family planning, citizenship, community development, occupations, home making, business management, national history, arts, and culture. In the future education in less developed countries must do more than the schools are now doing, for they are not reaching many school-age dropouts and many adults.

Though the central concern of our entire presentation is providing an optimal learning environment for a single organism--an individual student--practically in less developed countries this means we must be concerned with higher levels of living systems--groups (classes), organizations (schools and school systems), and societies (nations, and particularly their associator or subsystems). In a few projects the possibility of improving educational cost-effectiveness by international cooperation to share resources is considered, and this concerns the supranational level. The levels dealt with in a given project are determined by discovering at which levels most of the decision-making is going on. In the traditional teaching process the most important level is the group (the class). In closed-circuit television in a school or college it is the organization, although the group may also make decisions. In a national educational satellite system the society, organization, and group levels are all involved in decision making. If an international satellite were employed, the supranational level would also be involved.

Other principles which we accepted as bases for selecting projects and setting their priorities were the following, some of which are standard assumptions of educators generally but others of which are possibly controversial conclusions derived from observation of current practices in educational systems of various less developed countries:

- Since education is fundamentally an information processing activity, resources of personnel and equipment should preferentially be expanded to optimize the functioning of those information processing subsystems that carry out these processes and the matter-energy subsystems that provide the power and maintain the equipment necessary to carry out those functions. In many if not all lands, however, it has seemed natural to put large amounts of money first into school buildings--the supporter subsystem of the organization. We have mentioned above the status which a community achieves by having such buildings and the ernest permanency of the program which they represent. Also politicians get rewards from them--a concrete indication to the people that their taxes produce something and a memorial of the politicians to endure into the future and satisfy their "tombstone complexes." Especially in warm climates, however, expensive buildings may not be the best use of available funds. Prior concern should be not for the supporter but for the primary educational processes--training the teachers and providing instructional technology or whatever else will give the student the best learning environment. These can improve educational effectiveness, while building a school building does not necessarily, though it can increase costs markedly.

- Among the information processing subsystems of educational systems preferential consideration should be given to three:

(a) The associator, in which the actual learning process goes on, is of course, "where the action is."

(b) The channel and net, which by transmitting information rapidly over long distances, enables education to become more than a local process and permits regional, national, or even international sharing of educational resources.

(c) The decider, whether centralized or decentralized, which controls the entire system and is responsible for trying to optimize its cost-effectiveness.

In order to determine how well each of these subsystems, as well as all the others, are performing their functions we have developed a list of variables, or organizational indicators which can be measured for each subsystem.[9]

- The primary goal of educational research and development should be to improve the learning environment of the individual student by surrounding him with more competent teachers or paraprofessionals and/or more effective instructional technology. These aids to learning should, whenever possible, provide him with well planned curricula, rapid and accurate feedbacks about how well he is learning, multimodality inputs of information when they are the best means for learning, "branching" inputs which make it unnecessary for him to go over topics he already knows, and opportunity to progress at the optimal rate for his ability. Research and development throughout should center on the student and his welfare, not on the people and technologies that serve him.

- Social, geographical and cultural factors exert major influences on the learning environment, so the situation in each educational system differs and must consequently be treated appropriately in light of its particular characteristics. The choice of instructional technologies--if any--must be made in light of these characteristics. Illich has said that the less developed countries usually have accepted Western educational systems and instructional technology with the same alacrity with which they began to drink Coca Cola. Whether or not this is true, we must constantly remind ourselves that instructional technology is not inevitable or the only solution to education's problems.

- It is essential to identify clearly the subsystems and components which carry out each of the processes in an educational system. It is then possible to make an inventory of the system, measuring organizational indicators of each of the subsystem processes. After such an inventory the indicators which reveal functioning that is abnormal or low in cost-effectiveness should be reviewed to determine the nature of the pathology. Then changes in the structure or processes of the system's human components, or addition of artifacts to act as prostheses in it (see pages 41 to 42) should be recommended. These recommendations should, if it is possible, be carried out in an effort to improve the system's cost-effectiveness. The emphasis on costs (inputs) as related to effectiveness (outputs) (see pages 50 and 51) should be basic to the entire research program.

Just as there are several measures of costs (like the amount of matter-energy, personnel, information, money, or time required), so there are several measures of effectiveness of an educational system (like the relevance of its curriculum, the adequacy of training of its teachers, the motivation of its students to learn, how fast they learn, how much they remember, how many adults are served, how reliable the instructional equipment is, and so forth.

At our present state of understanding of the opportunities to make substantial improvements in education in less developed nations, it appears that the greatest cost savings may come from use of paraprofessionals rather than trained teachers, from mass instruction using broadcast media or other media available over networks, and from the availability of instruction by technological means at any time on demand. The greatest improvements in quality may come from careful planning and production of curricular materials for the media using formative evaluation, from instruction provided to very large audiences of students by the most expert teachers, and from the provision of excellent instruction in the immediate future by the media rather than waiting to train a new generation of teachers to carry out traditional modes of classroom instruction.

- Research and development projects undertaken should emphasize educational strategies which are sufficiently inexpensive to be practical for the particular educational system under consideration and which are sufficiently well developed to be capable of application in the near future. Many countries are spending about as high a percentage of their gross national product on education as they can. All feasible innovations, therefore, must cut unit costs.

- Consideration must be given to the ever present reality in less developed countries that even though sophisticated and effective hardware and software may be available, wages are so low that human beings rather than instructional technologies may provide the optimal feasible learning environment.

- The "small" instructional technologies which can be used in a single classroom or home should not be dropped from consideration without review in favor of the mass media just because the latter have had dramatic impacts in some situations.

- Effective software is at least as important to instructional technologies as satisfactory hardware and often it is much more difficult and costly to obtain or develop.

- Often educational research and development can be done better in established than in less developed countries, and--consistant with the principle of sharing resources when possible--the results can then be applied to less developed countries without necessarily having to be repeated there. We therefore include among selected projects only those basic researches which are essential to the improvement of education in less developed countries and which are not likely to be done under other auspices. In general we suggest that these projects take cognizance of basic research on the learning process and other topics which has already been done and build on it. But further basic research should usually be supported by foundations and such agencies as the United States Office of Education. When the less developed nations can afford to set up research centers on education and the instructional technologies, however, they should certainly do so. Such centers can stimulate indigenous innovations in education, improve the quality of instruction, and cut its costs.

The above principles were followed in selecting the 26 proposed projects outlined in Chapter V below, and they can become the bases for a continuing review of research priorities in future years.

The 26 recommended projects are mapped in Table 8, the large fold-out chart which appears at the end of this report.

2.1 Description of the Columns in Table 8. In Column 1 the number of the project appears. In Column 2 is its priority, determined in our best judgment in the light of the principles stated above. There are 13 projects of Priority A; 8 of Priority B; and 5 of Priority C. The title of the project appears in Column 3. Column 4 lists the system levels involved in it, two or more of the following--group, organization, society, or supranational system.

Each of the remaining columns is concerned with one of the educational system's subsystems. (The educational system is the associator subsystem of a particular nation.) We have included most, but not all of the critical subsystems listed in Table 1 on page 37. First come the matter-energy processing subsystems and then the information processing subsystems. Since education is primarily an information processing activity, the greatest attention is paid in most projects to the information processing subsystems, although the matter-energy subsystems should not be neglected because they are essential to all living systems. Some educators and social scientists, chiefly concerned with the advanced societal processes, tend to forget this.

We have, for convenience, combined the ingestor and the matter-energy storage subsystems in one column, Column 5. We do this simply because, though there are clearly different subsystems, the projects are not concerned with whether the matter-energy comes in from outside the system or is stored within it. Included in these two subsystems are, as the wording in this column for Project 1 indicates: "Persons and artifacts that supply electricity over power lines or from generators, or from batteries, for instructional equipment; or who bring radio and television sets into the places they are used for education."

In the next column, Column 6, is the distributor subsystem, which includes: "Persons who deliver instructional equipment or batteries for providing power for them, or who pick up and deliver such equipment needing repair from places they are used for education."

Next is Column 7, which represents another matter-energy processing subsystem, the producer. This includes: "Persons who manufacture or do maintenance on or repair instructional equipment and power sources; and persons who build schools."

In Column 8 is the supporter, which includes: "Persons who maintain and repair schools."

In Column 9 is the input transducer. It includes: "Persons who create or bring to the educational system information relevant to the culture and society, to courses, curricular planning, or use of instructional technology, or to educational planning or management."

Column 10 is the internal transducer, including: "Teachers or paraprofessionals who report test results or provide other feedbacks for formative evaluation; persons who make observations or reports indicating the nature of processes going on in parts of the system."

Column 11 is divided into three subcolumns, 11A, 11B, and 11C. Together they represent the channel and net subsystem. Since new forms of communications are central to much innovation in instructional technology, we have put this particular subsystem under the microscope and recognized that all channel and net subsystems have three major subcomponents: the transmitter, the channel, and the receiver. We find it useful for analysis to subdivide this particular subsystem into these three subcomponents. The transmitter includes: "Personnel and artifacts at educational television and radio stations; teachers and paraprofessionals and the instructional artifacts they use." The channel includes: Television and radio channels; face-to-face communication among teachers or paraprofessionals and students." And the receiver includes: "Television and radio receivers and students."

Column 12, the associator subsystem, includes: "Students, and remote and local teachers or paraprofessionals; and instructional artifacts; parents, family, and friends of students."

Column 13, the memory subsystem, includes: "Teachers, paraprofessionals, staff, administrators; artifacts used in instruction, such as books, maps, slides, printed programmed instruction, CAI and CMI programs, audio and video tapes."

We next come to Column 14, the decider subsystem. It includes: "Teachers, paraprofessionals, educational administrators, curricular planners, educational television and radio actors and producers, and artifacts such as computers for management and planning information systems; parents of students."

Last we come to Column 15, the output transducer subsystem. It includes: "(a) Educational administrators and other official spokesmen; (b) graduates or alumni; and (c) feedbacks from performance of graduates or alumni as basis for summative evaluation."

### 3. Distribution of Subsystems Given Major Emphasis in Different Projects

In each line representing a project in Table 8, one or more subsystems is surrounded by a heavy border. This identifies the main subsystem (or subsystems) toward which that particular project directs its investigation. The first column of Table 9 lists the 26 project numbers and the next column indicates the levels concerned in each project ("G" represents group; "O," organization; "S," society; and "Su," supranational system.) The totals at the bottom indicate that all 26 projects are concerned with the organization and the society level, since fundamentally we are dealing with national educational programs of less developed countries. In addition seven of them are concerned in some way with the group level and three represent investigations of possible supranational sharing of resources across national boundaries.

Each of the other columns of Table 9 represents one of the subsystems in Table 8 (and in the case of the channel and net subsystems, its three subcomponents). An "x" put in any box indicates a subsystem given primary consideration in that particular project. The totals along the bottom indicate what would be expected: since educational systems are concerned mainly with information processing, there are relatively few projects related primarily to matter-energy processing subsystems. Such issues as the availability of equipment to provide electrical power, however, are critical for the use of much educational technology. But the greatest emphasis obviously is on

| No. | Levels* | Ingestor or Matter-Energy Storage | Distributor | Producer | Supporter | Input Transducer | Internal Transducer | Channel and Net |  |  | Associator | Memory | Decider | Output Transducer |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  |  | Transmitter | Channel | Receiver |  |  |  |  |
| 1 | G,O,S |  |  |  |  | x | x |  |  |  |  |  |  | x |
| 2 | O,S |  |  |  |  |  |  | x | x | x | x |  |  |  |
| 3 | O,S |  |  |  |  |  |  | x | x | x |  |  |  |  |
| 4 | O,S |  |  |  |  |  |  |  | x |  | x |  |  |  |
| 5 | O,S |  |  | x | x |  |  | x | x | x | x | x | x |  |
| 6 | O,S |  |  |  |  |  |  |  |  |  |  |  | x |  |
| 7 | O,S |  |  |  |  |  |  |  |  | x |  |  |  |  |
| 8 | G,S |  |  |  |  |  | x |  |  |  | x |  | x |  |
| 9 | O,S |  |  |  |  |  |  |  | x |  | x |  |  |  |
| 10 | O,S,Su |  |  |  |  |  |  | x | x | x | x | x |  |  |
| 11 | O,S,Su |  |  |  |  |  |  | x | x |  |  |  | x |  |
| 12 | G,O,S |  |  |  |  | x |  | x | x | x | x | x | x |  |
| 13 | G,O,S |  |  |  |  |  |  | x | x | x | x |  |  |  |
| 14 | O,S |  |  | x | x |  |  | x | x | x | x | x | x |  |
| 15 | O,S |  |  |  |  |  |  | x | x | x | x | x | x |  |
| 16 | O,S |  |  |  |  |  |  | x | x | x |  |  |  |  |
| 17 | G,O,S |  |  |  |  |  |  | x | x | x | x |  |  |  |
| 18 | O,S,Su |  |  |  |  |  |  | x | x | x |  |  |  |  |
| 19 | O,S |  |  |  |  | x |  |  |  |  |  |  |  |  |
| 20 | O,S | x |  | x |  |  |  |  |  |  |  |  |  |  |
| 21 | G,O,S |  | x | x |  |  |  |  |  |  |  |  |  |  |
| 22 | O,S |  |  |  |  |  |  |  |  |  |  |  | x |  |
| 23 | G,O,S |  |  |  |  |  |  |  |  |  | x |  |  |  |
| 24 | O,S |  |  |  |  |  |  | x | x | x | x |  |  |  |
| 25 | G,O,S |  |  |  |  | x |  |  |  |  | x |  |  |  |
| 26 | O,S,Su |  |  |  |  |  |  |  |  |  |  | x | x |  |
| Total | G,8;O,25;<br>S,26;Su,4 | 1 | 1 | 4 | 2 | 4 | 2 | 13 | 15 | 13 | 14 | 6 | 9 | 1 |

* G = Group
O = Organization
S = Society
Su= Supranational System

Table 9. The Levels and Main Subsystems Involved in Each of the 26 Projects

information flows in the three components of the channel and net subsystem, 13, 15, and 13 projects respectively. This is because communications technologies, which represent prostheses to the various subcomponents of the channel and net subsystem, constitute such important aspects of instructional technology. The learning process is also central, and consequently 14 of the 26 projects emphasize the associate subsystem, which is the main subsystem of the total educational system where the learning goes on. Management is also important in these systems, as in all other social systems, and so the decider subsystem has 9 researches related to it. Finally, information is not only processed currently in these systems, but also is stored and retrieved, so 6 of the studies deal with the memory subsystem. These are the major emphases in these research projects. It is interesting, however, to see that a wide range of subsystems is studied in the 26 projects included in this research map. In a sense Table 9 summarizes the systems aspects of the research map, which is Table 8.

We shall now proceed in the final chapter to outline each of the proposed projects in detail.

## CHAPTER IV

## Notes and References

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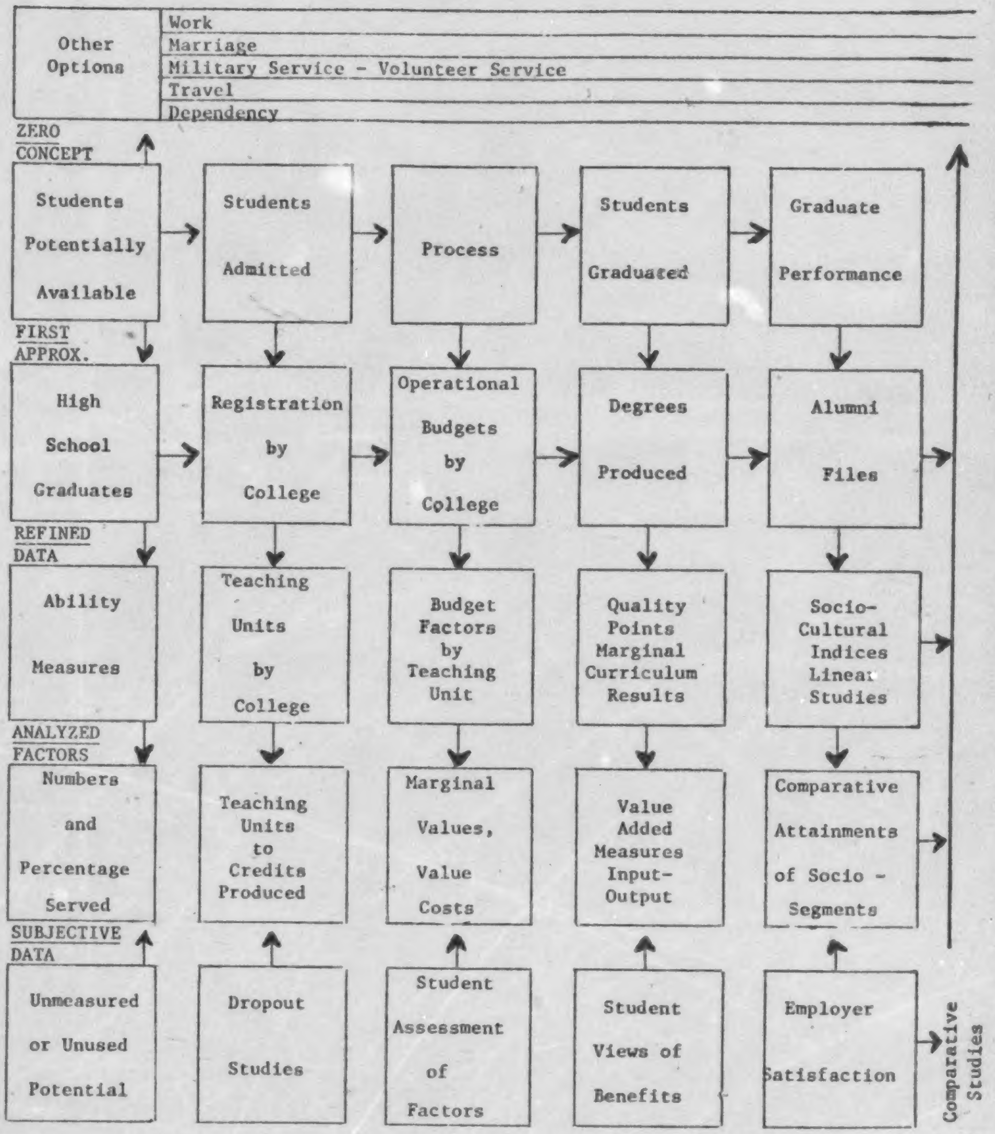
Other Options
Work
Marriage
Military Service - Volunteer Service
Travel
Dependency
ZERO CONCEPT
Students Potentially Available
Students Admitted
Process
Students Graduated
Graduate Performance
FIRST APPROX.
High School Graduates
Registration by College
Operational Budgets by College
Degrees Produced
Alumni Files
REFINED DATA
Ability Measures
Teaching Units by College
Budget Factors by Teaching Unit
Quality Points Marginal Curriculum Results
Socio-Cultural Indices Linear Studies
ANALYZED FACTORS
Numbers and Percentage Served
Teaching Units to Credits Produced
Marginal Values, Value Costs
Value Added Measures Input-Output
Comparative Attainments of Socio - Segments
SUBJECTIVE DATA
Unmeasured or Unused Potential
Dropout Studies
Student Assessment of Factors
Student Views of Benefits
Employer Satisfaction
Comparative Studies

Table 10. Task Force IV Evaluation Model

[From Task Force IV, Connecticut Commission for Higher Education (R. A. Rosenbaum, Chairman). Qualitative and quantative performance and achievement in higher education. Hartford, Conn.: Connecticut Commission for Higher Education (ERIC ED 048 833), January, 1971 9.]

# CHAPTER V

## The 26 Projects

On the bases described above we recommend for implementation 26 projects on instructional technology in less developed countries. We shall describe them below in the order in which they are listed in Table 8. For each one we shall present the following:

(1) Statement of overall objectives (to what development applications will the results of the research or development work lead?); also, statement of the intermediate goals or targets to be reached.

(2) Indication of the levels and subsystem or subsystems of the educational sector (*i.e.*, associator subsystem) of the society chiefly involved in this study.

(3) Brief review of existing relevant research, particularly that with a development orientation, indicating the gaps and promising trends.

(4) Description of how the research project will be carried out.

(5) Analysis of the staff and time schedule required to reach research objectives.

(6) Analysis of the steps required to transform research findings into operational use.

(7) Plan for coordination with other research and development work in a related project.

(8) Indication of the kinds of professional expertise required for the project.

(9) Estimates of costs analyzed in terms of professional and supporting personnel costs, travel, and report preparation. And (10) suggestions of less developed countries which would be appropriate locations for such a project because of the potential benefits they could derive from it.

The word "research" can be applied to all the 26 projects listed below if it is used broadly. Some of the studies have the character of experimental research, in which a specific set of hypotheses is tested by precisely measuring certain variables under tight controls. But the other projects include simulations, model designs, engineering feasibility studies, case studies, pilot projects, market surveys, system analyses, and development activities. We believe that the present state of instructional technology in less developed countries demands such a broad rather than a narrow definition of research limited to experimental hypothesis testing.

The objectives of the studies are also diverse. They include studies of comparative cost-effectiveness, cost analyses, feasibility studies, forecasts of needs or resources, and efforts to improve ongoing operations.

A major step in designing specific research projects is analyzing an important, complex question into several smaller questions that are susceptible to investigation by the techniques of behavioral science. Many aspects of behavioral science are in such early states of development that we cannot obtain satisfactory answers to some of the most important questions. When faced with the alternative of answering an important question crudely or a trivial question precisely, we have chosen the former. We have done this for two reasons: (a) that decision makers in less developed countries urgently need to have more information to base their decisions upon even if that information is tentative; and (b) that crude analyses often must precede sharper, more focused, studies of a phenomenon. We have, however, tried to plan all the projects so that ultimately the validity of their conclusions can be evaluated.

In every case, also, we stress the need to study the entire system with all its living and nonliving parts, as well as all their relationships and interactions, and not a single subsystem or component abstracted from the others for purposes of analysis. It is essential to consider a wide range of variables in analyzing the potential impact of any one technology on an educational system. Everything must be taken into consideration from the character of the decision makers to the characteristics of each medium. The following are some of the aspects of the systems which must be evaluated:

- The social, cultural, and political setting in which the medium is to be introduced
- The organization and procedures of the educational system
- The type of educational administrators and decision makers involved
- The organization and procedures of the unit that produces the instructional materials
- The kind of content to be conveyed
- The characteristics of the medium providing the information inputs
- The characteristics of the transmission system
- The characteristics of the students
- The responses expected from the students

- The characteristics of the teachers or monitors involved in the student-input interaction.
- The training of the teachers or monitors
- The activities occurring between those teachers or monitors and the students
- The design and performance of the equipment used
- The feedbacks between instructional and noninstructional personnel
- The feedbacks between (a) the student, (b) the teachers or monitors, and (c) the programmers of the instructional materials
- Monetary and other costs

This is a partial list. The total list of factors is long, almost to the point of incomprehensibility. Each of the items mentioned above has numerous individual variables.

In the implementation of the projects outlined below, we recommend the minimum possible use of foreign experts consistent with competent research and the maximum use of nationals of the less developed country involved. Some of the latter may need first to be trained in the United States or some other established country in order to learn how to conduct dependable and conclusive researches. Every one of the projects may well lead to educational innovation, and it is desirable for constructive innovation to be accepted and implemented. Such acceptance is likely to be accelerated greatly if the problems are identified by citizens of the country rather than aliens, and if they state the hypotheses, design the researches and make the plans and proposals.

## 1. Proposed Project 1, Priority A

## METHODOLOGICAL STUDY OF EDUCATIONAL COST-EFFECTIVENESS EVALUATION

This is a methodological study of how best to carry out cost-effectiveness evaluation of formal and nonformal education, either when (*a*) modern information processing media are used or (*b*) when they are not.

1.1 Objectives. The aspect of education using instructional technology which most urgently needs exploration is how its cost-effectiveness can be systematically and rigorously evaluated. Methods for measuring the costs of a given educational activity--which make up the numerator of the cost-effectiveness ratio--in such units as amount of money spent, number of personnel employed, or time required, are fairly well understood. But methods for quantifying effectiveness--which is the denominator of the ratio--are in early stages of development. More research to improve these methods is essential.

There are two sorts of educational evaluation, formative and summative. The former is a rather new concept; the latter has been employed for centuries. Formative evaluation, according to Bloom, is:[1] "the use of systematic evaluation in the process of curriculum construction, teaching, and learning for the purpose of improving any of these processes." Summative evaluation is:[2] "the type of evaluation used at the end of a term, course, or program for purposes of grading, certification, evaluation of program, or research on the effectiveness of a curriculum."

Both of these kinds of evaluation represent the use of negative feedbacks by the educational system with the objective of maintaining a high quality of instructional information flowing through the system in ways that will best facilitate student learning. Formative evaluation is a comparison of inputs (costs) with outputs (provision of effective or quality services or products) of a part of the total system. It is carried out during the preparation of instructional materials before they are transmitted to any of the students (except a small sample used as a population on which to pretest them). It is conducted by curriculum developers, teachers, and paraprofessionals who report pretest results or provide other feedbacks. These persons, when they do this, are parts of the system's internal transducer subsystem. On the other hand, summative evaluation is a comparison of the inputs (costs) with the outputs (provision of effective or quality services or products) of the total system. Ordinarily it takes longer than formative evaluation because the system must finish its services to the student, test him before graduation, and then follow him as an alumnus performing in the society for some time before it can complete a summative evaluation. This is done by (a) spokesmen that request informational feedbacks about the performance of graduates or alumni, who are parts of the output transducer subsystem, and (b) others that complete the feedback loop by transmitting to the educational system from its environment information about the performance of its alumni in the society.

The first objective of the proposed project is to improve the procedure for formative evaluation of various sorts of formal and nonformal education, both those involving teachers and traditional classroom procedures and those involving paraprofessionals or instructional technology. Such evaluation must make allowances for the particular characteristics of the society and culture in which the education occurs. Employing feedbacks in the creation of curricular materials assumes that the instruction can be more successful when the program format and schedule are modified by user reactions. For example, an artistically designed set of lecture-demonstrations may be pedagogically inappropriate for some students. Unless the staff has some way of both testing the effects of the program and modifying it in the light of these data, the instruction will not be optimally effective. To achieve the best possible performance, one must employ feedback loops including program development, followed in order by program presentation, student reception, analysis of student reaction data, and consequent modification of program development.

It is common practice for curricular materials to be used in such media as face-to-face lectures, instructional radio, instructional TV, or cassettes, to be planned to extend over some given time span in a set manner. The plan decided upon at the beginning of the course is followed as program after program is produced. No effort is made to improve the lessons on the basis of reactions of a sample of learners, at least until the end of a formal course when some revisions may occur as the next year's course is planned. It is particularly hard to feed back results of instruction to teachers or curricular planners who use media that do not provide them direct access to their students. It is worthwhile to try to render the TV instructor, for example, as responsive to learner needs as the traditional face-to-face instructor can be.

The second objective of the proposed project is to improve summative evaluation of formal and nonformal education. This should involve development of reliable methods of quantifying the various sorts of inputs and outputs of the total system, as well as all its component subsystems and technological prostheses. The usual procedures of engineering evaluation should be applied to the technological aspects, but educational evaluation is more than that. It must measure the joint impact of the living and nonliving components of the entire educational system.

1.2 Levels and subsystem or subsystems involved in this study. Group, organization, and society levels. Components of the internal transducer subsystem provide feedbacks about instructional materials during their preparation. Components of the output transducer subsystem request feedbacks about the performance of graduates or alumni, and components of the input transducer subsystem convey such feedbacks into the system.

1.3 Existing relevant research. A large literature of studies on educational cost-effectiveness has developed during the past five years or so. In 1969 a bibliography on systems analysis for educational planning, many of the documents in which concerned cost-effectiveness analysis, was published by the Organization for Economic Co-Operation and Development.[3] It contained 306 references. We can mention only a very few of these here.

Balderston and his associates have made a general survey of cost analysis and of planning-programming-budgeting systems (PPBS) in education.[4] Among other things these studies revealed that a number of different sorts of resources are expended by educational systems and that there are many ways to calculate such costs. They also indicated that the benefits derived from PPBS budgeting may not be enough to justify its costs.

Obviously the measurement of educational costs is much more sophisticated than the measurement of educational effectiveness. Some scholars, like Bloom and his associates, however, have devoted much attention to this problem.[5] They have been concerned primarily with the determination of educational objectives as well as development, standardization, and administration of cognitive, effective, and behavioral tests in both formative and summative evaluation of the effectiveness of various sorts of educational programs. Generally these are tests administered within formal educational systems rather than follow-up tests on graduates or alumni, or tests for adults or others participating in nonformal education.

One important kind of research on formative evaluation has been conducted by Gorth, Dumont, and Wightman at the University of Massachusetts.[6] This concerns what they call Comprehensive Achievement Monitoring, which is the testing of students at frequent intervals during instruction (_e.g._, every two weeks), as well as after instruction, with monitors or tests designed to evaluate achievement on each one of a set of previously specified objectives of the educational program. At each test administration performance is evaluated as to (_a_) objectives not yet dealt with, (_b_) those just dealt with in the immediate past, and (_c_) those dealt with earlier in the course. Computer-based analyses and reports are made to teachers and students to aid them in adapting study patterns, pacing and sequencing instruction, developing curricula, and improving the quality of education. This approach analyzes multiple variables of the learning process including sociological variables such as family and social backgrounds of the students, school-related variables such as expenditures per student and urban or rural location, and student variables such as rates of learning and retention, personality, and vocational interest patterns.

Much research has been carried out on various approaches to summative evaluation. One of these is cost-benefit analysis, such as has been described by Woodhall, and by Goffman and his associates.[7] This technique, developed chiefly by economists, views education as an investment by the individual student and his family and by the nation, which yields economic benefits to them and contributes to their future wealth by increasing the student's productive capacity. Educational inputs and outputs, costs and benefits, are both measured in the same monetary units. Various forms of economic calculations can be employed to determine which is the optimal educational program in terms of cost-benefits. For instance, Hirsch and Marcus have used such calculations in an analysis of the desirability of universal junior college education in the United States.[8] This "econocentric" analytic approach seems too simplistic, since both the inputs to and the outputs from educational systems are of several sorts. As Alkin, as well as Carpenter and Hoggart, point out, all aspects of them cannot be measured in monetary units.[9]

One cost-benefit approach outlined by Blaug takes into consideration, in addition to finances, a less developed country's current, and forecasted future, manpower needs.[10] Recognizing that a nation's educational system and labor market have reciprocal impact, he describes how cost-benefit analyses can be made in terms of how well the educational system meets the nation's needs for trained manpower.

As an improvement over cost-benefit analyses Alkin proposes a model for cost-effectiveness summative evaluation of educational systems. It includes:[11]

"'student inputs'--the characteristics of students entering the system; 'educational inputs'--cognitive and noncognitive changes that occur in students after exposure to an instructional program; 'financial inputs'--financial resources available to carry on the program; 'external systems'--the social, political, legal, and economic structure of society; and, lastly, 'manipulable characteristics'--those aspects of the program which are resource-consuming and which are administratively manipulatable."

This is one approach to cost-effectiveness, but in recent years there have been a good many others. Most of them agree that outputs of educational systems must be measured to determine their effectiveness. Most agree that no single dimension is enough to measure those outputs. The search for output measures which indicate the quality of performance of an educational institution in the last five years or so has challenged many thoughtful persons interested in systems analysis. For example, Hanushek suggested that the quality of outputs of schools be measured by the percentage of students entering the school who complete each grade, the percentage who attend college, and their achievement scores.[12] Turnbull listed another set of possible measures, both "scholastic" and "secular," for institutions of higher learning:[13] Qualifications of students admitted, as indicated by how selective the system is in admitting its students, the percent of the matriculants from the top quarter of the class, the level of admissions test scores, or the proportion of National Merit Scholars. Qualifications of graduates, as indicated by the percentage who go on to the best graduate and professional schools, earn high awards, and receive high-salaried jobs. The average "value added" to students between input and output, the amount of learning or growth of students between their admission and their graduation. Nonacademic measures of an institution's quality include its power to engender commitment to moral, social, and political causes; its respect for self-direction; its provision for self-governance; its sense of shared purpose and high morale; its respect for expanding and transmitting human knowledge; and the strength of ethical commitment of its graduates. Research criteria such as the probability that an institution's scholarship will advance knowledge importantly or better man's lot. Service criteria such as how much the institution contributes to many aspects of society.

Another approach to measuring the quality or effectiveness of the outputs of an educational system (a university) was outlined by Brown.[14] First he identified a set of goals or objectives for the system. Then he suggested measures for each. Here are two out of 20 examples:

| Goals or Objectives | Measures |
|---|---|
| Learn to retain facts | 1. Student testimony, *e.g.*, answer to question: "While in college has your factual knowledge: 'more than doubled,' 'increased some,' 'remained about the same,' or 'decreased'?" |
| | 2. Difference between percentile rank on Graduate Record Examination (or substitute exam) and percentile rank on Scholastic Aptitude Test. |
| | 3. Difference between "before" and "after" reading-listening test on totally new material. |

| Goals or Objectives | Measures |
|---|---|
| Provide benefit to town citizens | 1. Faculty testimony, e.g., during the past year town residents not directly associated with the university benefitted from the university's presence: 'a great deal,' a modest amount,' 'not at all,' or 'negatively.'<br>2. Change in number of part-time students enrolled.<br>3. Change in number of public lectures and performances given. |

He goes on to outline how each of the 20 measures can be given a weighting so that a total index of output effectiveness of the system can be calculated.

A somewhat similar approach to the assessment of educational quality in schools has been followed by Beers.[15] It involves the statement of 10 goals and the development of sophisticated measures of the progress of the system toward their achievement, tests which were administered to fifth grade and eleventh grade students. The 10 goals were stated as follows:

Quality education should help every child

- Acquire the greatest possible understanding of himself and an appreciation of his worthiness as a member of society.
- Acquire understanding and appreciation of persons belonging to social, cultural, and ethnic groups different from his own.
- Acquire the fullest extent possible for his mastery of the basic skills in the use of words and numbers.
- Acquire a positive attitude toward school and toward the learning process.

- Acquire the habits and attitudes associated with responsible citizenship.

- Acquire good health habits and an understanding of the conditions necessary for the maintaining of physical and emotional well-being.

- Obtain encouragement to be creative in one or more fields of endeavor.

- Understand the opportunities open to him for preparing himself for a productive life and enable him to take full advantage of these opportunities.

- Understand and appreciate as much as he can of human achievement in the natural sciences, the social sciences, and the arts.

- Prepare for a world of rapid change and unforeseeable demands in which continuing education throughout his adult life should be a normal expectation.

The measuring instruments administered to students to determine how well each goal was being achieved differed. For example, the inventory used with fifth grade students to assess progress toward the first goal contained 53 test items, 47 from the Self-Esteem Inventory developed by Coopersmith and 6 from the Equality of Educational Opportunity survey developed by Coleman and his associates.

A relatively complex model for evaluating qualitative and quantitative performance and achievement in higher education was created by Rosenbaum and his associates on Task Force IV of the Connecticut Commission for Higher Education.[16] This model is two dimensional. In Table 10 from left to right appears the flow of the

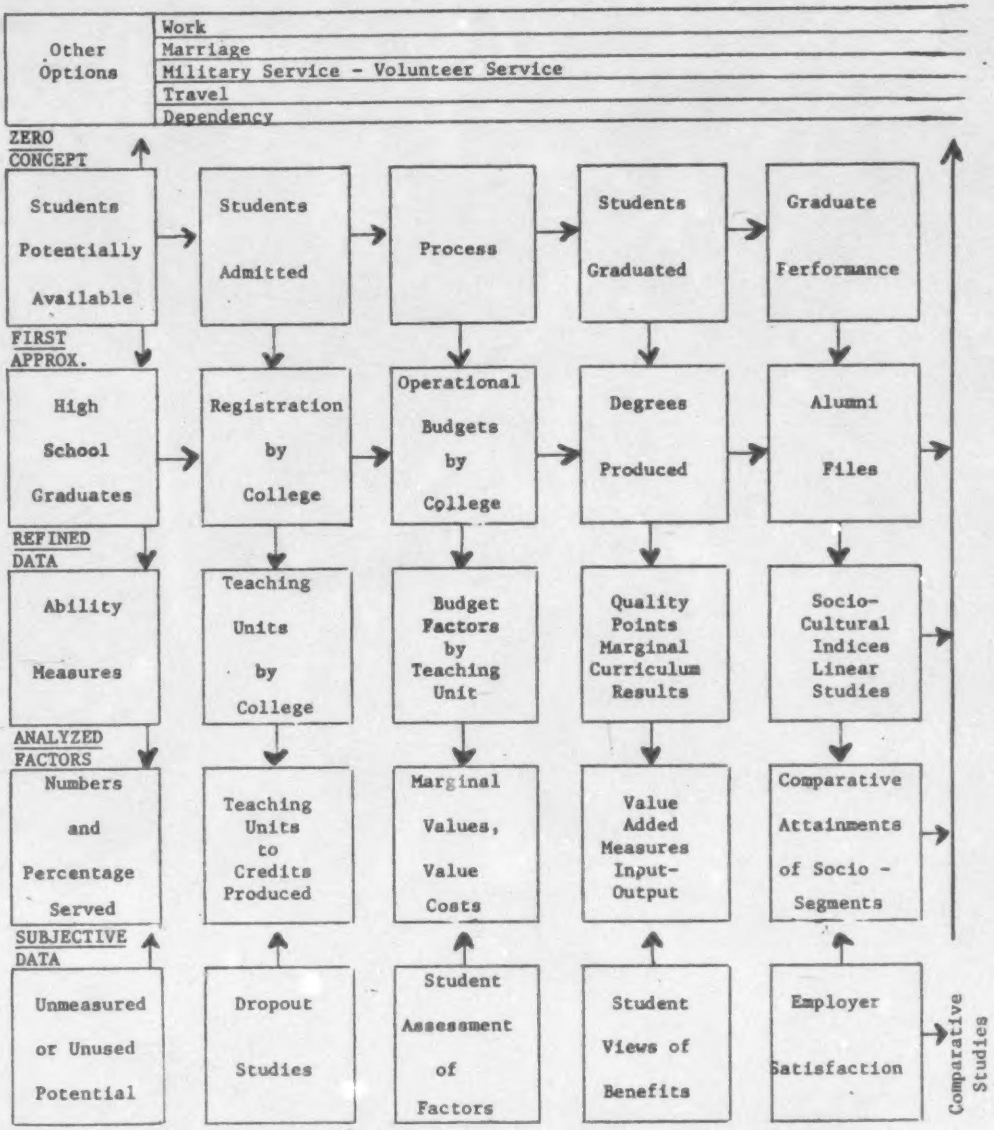
Other Options
Work
Marriage
Military Service - Volunteer Service
Travel
Dependency
ZERO CONCEPT
Students Potentially Available
Students Admitted
Process
Students Graduated
Graduate Performance
FIRST APPROX.
High School Graduates
Registration by College
Operational Budgets by College
Degrees Produced
Alumni Files
REFINED DATA
Ability Measures
Teaching Units by College
Budget Factors by Teaching Unit
Quality Points Marginal Curriculum Results
Socio-Cultural Indices Linear Studies
ANALYZED FACTORS
Numbers and Percentage Served
Teaching Units to Credits Produced
Marginal Values, Value Costs
Value Added Measures Input-Output
Comparative Attainments of Socio - Segments
SUBJECTIVE DATA
Unmeasured or Unused Potential
Dropout Studies
Student Assessment of Factors
Student Views of Benefits
Employer Satisfaction
Comparative Studies

Table 10. Task Force IV Evaluation Model

[From Task Force IV, Connecticut Commission for Higher Education (R. A. Rosenbaum, Chairman). Qualitative and quantative performance and achievement in higher education. Hartford, Conn.: Connecticut Commission for Higher Education (ERIC ED 048 833), January, 1971 9.]

student population from precollege, through college, to postcollege. The top row represents the most naive approximation, based on simple numerical statistics. The analyses of each lower row are progressively more sophisticated to the bottom one designed to attend to qualitative considerations.

In order to clarify the model we present definitions of the terms in the first row. Each of the boxes refers to a quantitative measure.

1. "Students Potentially Available."--The size of the precollege population and the distribution of measurable abilities within identifiable segments of this group. Measurable abilities shall include new measures of students' unique talents which differ from the common aptitude and achievement scores that are presently weighted excessively in admission procedures.

2. "Students Admitted."--The characteristics of those who enter college: Measurable abilities and demographic statistics.

3. "Process."--A statistical analysis of the process of formal education: size of faculty, administration, and staff; distribution by educational background, age, professional experience; teaching loads; class size; size and nature of facilities (libraries, laboratories, classrooms, etc.); allocations of resources for general educational support (psychological services, cultural events, etc.).

4. "Students Graduated."--The characteristics of those who leave college through graduation or otherwise: unit costs per academic credit earned, degree granted, and the like; attrition rates; postcollege plans. Specifically, "value added" as measured by the

development from "students admitted" to "students graduated," as distinct from general maturation which might occur without college.

5. "Graduate Performance."--Characteristics of individuals five, ten, or more years after leaving college; differences between graduates and nongraduates, including in the latter group those who did not enter college.

In terms of this model, the goal of an evaluative procedure is to approach as closely as possible to the most refined approximation in the bottom row of Table 10. This does not mean that quantitative measures are to be ignored; indeed, it is expected that imaginative efforts will result in the evolution of numerical indices having good correlation with those qualitative characteristics of successful education. The relative ease of amassing statistical data should not hide the importance of probing for the fundamental, tenuous, and often elusive, qualities of effective higher education.

When a technological system is used for communication or delivery of instructional aid, its cost-effectiveness from an engineering viewpoint can be evaluated, in addition to its educational effectiveness. Several studies at the Stanford Electronics Laboratories have developed models and computer programs, for example, for the comparative evaluation of alternative terrestial, celestial, and mixed communications systems for instructional technology.[17] The final measure of cost-effectiveness of an educational system employing such communications is a complex joint function of the measures of educational and engineering cost-effectiveness.

Another research approach to cost-effectiveness evaluation is the use of mathematical models and computer simulations of educational systems. A review of such work was written by Bell for the Carnigie Commission on Higher Education.[18] It is clear that, though they have many weaknesses and shortcomings of such models and simulations as those of Koenig, Judy, Weathersby, and many others, they can be used to improve the cost-effectiveness of educational systems.

A major example of cost-effectiveness evaluations of an educational program using instructional TV in the United States is the follow-up study of "Sesame Street."[19] This program now is being exported to other countries in the original format or in translated or re-enacted formats to other nations including Germany, Mexico, Brazil, and various less developed countries.

Most of the research discussed above has been conducted in established nations without much consideration of the less developed nations, although a great deal of it is applicable to their problems. There have been some educational evaluation studies in less developed countries, however. One of them is a carefully designed experiment on the use of midcourse feedback to improve a program of instructional technology--in this case, television. In 1970, an evaluation testing program was begun in the El Salvador television project. Tests were designed for seventh grade mathematics and social studies and administered by TV to all seventh grade classes in the country. The research team from Stanford's Institute for Communication Research observed the tests being given and then intensively analyzed the data from 14 classes. They concluded that this study provided answers to the questions they had posed.[20]

'Procedures for obtaining short-range, yet detailed information on student learning from television were established. This information helped the television production personnel identify concepts that had not been adequately learned by students within a specific unit of material. Limited corrective action was undertaken by the subject-area teams to remedy the learning deficiencies, but more could, in principle, have been done along this line." The teachers and students favored the use of such tests even though they had little direct impact on the quality of the programs that were being produced.

The Stanford research team identified six problems that would have to be addressed in any further research and development on feedback systems in El Salvador. These include:

- The lack of training or experience in modern test construction among educators in that country.
- A severe limitation on the number of letters that can be presented at any one time in tests administered on the TV screen.
- The optimal duration of presentation of TV test questions.
- The most rapid and efficient collection of test results.
- Application of feedbacks to improve program quality.
- Making just the right amount of adjustment in programs in the light of formative evaluation feedbacks.

The El Salvador experiment has indicated that feedbacks concerning new curricula can be obtained for purposes of formative evaluation. It still remains to be determined what the best means of feedback are, how this feedback can be translated into corrective action in programming, how a feedback system can be expanded to include direct indications to learners and classroom teachers of learning outcomes, and how costly a thorough going feedback system will be. In El Salvador testing is done by TV, but there is no convincing evidence to warrant a firm conclusion that this is the best way to give tests for formative evaluation. Research and development need to be done on alternative means of obtaining feedback. Also, the large gap between the desired speed of response and the actual conditions of communication in less developed countries suggests that more needs to be done to ensure that the responses are fed back to program producers in a timely fashion. Equally critical is the need to train curriculum producers so that they will make constructive use of the feedback information they get. It was found in El Salvador that the urgent necessity to prepare lessons in time often prevented the programmers from adequately considering and acting upon the results of the evaluation.

A summative cost-effectiveness evaluation of the El Salvador educational TV project was carried out by Speagle.[21] He analyzed its budget and what measures of its impact were available. He made a preliminary estimate that the program in junior high schools raised costs per student 15 percent, but he concluded that further expansion of the program should reduce the costs per student. Up to the present there have been no large scale improvements in student learning derived solely from TV. The TV, however, had produced significant savings because it justified cutting down the retraining period of junior high school students from two years to one year. Speagle concluded that cost-effectiveness would not clearly rise until the student-teacher ratio is increased or similar changes leading to greater productivity are made, such as using the TV system also for teacher training or adult education.

Cost-benefit studies have been carried out by Blaug, Layard, and Woodhall, and by Nalla Gounden in India; by Schultz and Carnoy in Latin America; and by Smyth and Bennett in Uganda.[22] They all showed that the benefits to the society per unit cost from primary education were greater than from secondary or higher education. In Jordan a cost-benefit study was done which made it clear that one specific alternative form of technical education was much preferable, from that point of view, to another.[23]

In a Brazilian survey of evaluation of the use of educational technology and the development of nonformal alternatives and supplements, it was observed frequently that although people are assigned to do evaluations, what they do does not yield the sort of information that can be used to make specific changes in instructional programs.[24] For example, most evaluations emphasized description of the audience reached by a given project. Such emphasis on static description often fails to examine crucial issues like the following:

- Is the audience actually reached the same as the planned target audience, or is it perhaps a different population altogether? Nonformal education often reaches the same people that could be trained by formal education.

- Is the audience being changed in any important way by what they are receiving, or is the program not causing effective learning? Evaluations of cognitive recall alone are seriously inadequate as a basis for determining important changes in the audience.

- To what extent are the instructional procedures attuned to the cultural setting and ethnographic characteristics of the target audience? Or is it assumed that one set of instructional procedures can be similarly effective with all potential learners in a large and complex nation? The admirable idealism of a unified Brazil is compatible with the providing of differentiated learning experiences, tailored to fit the backgrounds of learners. Ignoring this problem will produce highly discriminatory educational curricula in which the masses will often be asked to accommodate themselves to the standards and characteristics of the educated minority.

- To what extent is the content of education relevant to the vital needs of the various target audiences, or is it assumed that relevant high quality education is the same thing for everyone? Despite the Brazilian Education Reform Law, serious miscalculations of the learning potentialities of the masses are still likely to occur.

It is now being gradually recognized by top educators in Brazil, partly through the impact of SATE, the agency assigned to plan educational evaluations throughout the country, that questions like the foregoing are central to the evaluation process.

Another aspect of cost-effectiveness evaluation of Brazilian schools has been addressed by Wolff.[25] He used data on student enrollment and repetition of grades by students in primary schoo[illegible] which were reported by the schools of each state to the Ministry of Education and Culture. From these he calculated an estimate of "school efficiency," defined as the fraction of children entering primary school who complete the full course. On this index of effectiveness the Brazilian states differed widely: States with high per capita incomes, like São Paulo, Guanabara, and Rio Grande do Sul, had high scores on school efficiency, and those with low per capita incomes, like Acre, Maranhão, and Amazonas, had low scores. Wolff had no data on the relation of the use of instructional technology to "school efficiency," and indeed its use in Brazil is not yet so widespread that such data would be particularly useful.

In certain other countries--Korea, Niger, and the Ivory Coast, for instance--some research on educational evaluation is being undertaken, but so far this work is not far advanced.

In the last five years a rapid acceleration of interest has occurred, among social scientists and some government officials, in social indicators of the cost-effectiveness of the various major sectors of a nation.[26] At the same time interest has increased in developing organizational indicators of the cost-effectiveness of the main subsystems of a wide range of profit and nonprofit organizations--farms, corporations, government agencies, hospitals, schools, universities, welfare agencies, courts, prisons, and so forth.[27] The above rather lengthy review of research represents only a small sample of the studies in the field. It is apparent that a science of the evaluation of organizations is emerging which will probably be applicable across the various types of organizations. It is equally apparent that much more methodological research must be conducted before this is a full fledged scientific field capable of rigorous application.

1.4 The research design. It is proposed that a five-year activity be undertaken to develop each aspect of the science of evaluation of educational programs until a rigorous, reliable, and valid procedure is worked out which has general acceptance by a range of experts in the field from various nations. This procedure should be detailed in such a way that it is applicable to a wide range of formal and nonformal educational programs, from the primary grades through graduate and professional schools and continuing education. It should be applicable to both formal and nonformal education. It should be sensitive to social, cultural, and ethnic differences among students. Also it should allow for the introduction of instructional technologies of any sort that potentially could improve the program under consideration.

Many of the other proposed projects which are outlined below include cost-effectiveness analyses. All of these can be carried out more adequately if the state of the art of educational evaluation is improved. This project therefore has the highest priority of all, because, if it accomplishes its goals, its findings can be used in many subsequent researches and applications.

The application of educational technology to the improvement of cost-effectiveness in formal and nonformal education depends on the development of procedures to (_a_) clearly specify purposes, goals, and objectives; (_b_) design instructional experiences to achieve these purposes, goals, and objectives; (_c_) evaluate the extent of accomplishment of these purposes, goals, and objectives; and (_d_) use the evaluative data as a basis for altering and improving the instructional experiences.

When instructional technologies are introduced into educational systems, one or more prostheses are made available to aid the human beings in the system. This may or may not relieve them of processes they are carrying out or reorganize those processes. It is desirable insofar as possible to introduce these technologies into the system only after cost-effectiveness analyses are made and reviewed. Sometimes these can be quite precise and quantitative, particularly if management information systems exist in the educational system which provide data relevant to these decisions. Under other circumstances, only a rough calculation of costs and benefits or effectiveness is possible by present methods, either because the relevant data are not available or because so many variables are involved that it is not feasible to measure them or to collect information about them. Below is a series of fictional examples of how such an approach might be taken to decisions on whether to use new instructional media in educational systems at various levels. Some of these examples may not be applicable to less developed nations because they are too costly, but others concern systems like some now operating in less developed countries. The evaluation methodologies illustrated are applicable in every nation.

(a) A school. An elementary school which has a large number of underprivileged children concludes that it may be desirable to use carrels in its first grade classrooms. Its purposes in using such carrels include: (a) To socialize children to the learning environment of the school by giving them periods when they are isolated from most extraneous information inputs and can carry out independent learning experiences. (b) To prepare the children for independent study in automated carrels which the school expects to introduce within two years at grades 3 and above.

Carrels are booths which constitute an interface between the student and some artifact from which he can receive information inputs. They can be classified into two general types: general space carrels, an enclosure with a door by which the student may isolate himself from the environment for periods of self-initiated study; and multimedium carrels, which include in the booth a typewriter on-line to a computer terminal, a source of auditory inputs, a screen capable of showing letters or figures, graphic materials or television pictures, and a light pencil with which the student can respond to inputs by pointing to any part of the screen, which signals the computer where he is pointing.

Inside the general space carrel the student could use a book, a television set, a projector showing slides or movies on a little screen, or a record player with headset. In terms of effectiveness in learning how to carry out tasks in multimedium carrels, such a carrel would probably be best for the first grade, even though the students could not yet type, although they might push a few keys to send a limited repertoire of signals to the computer. They easily could look at the screen, use the light pencil, and listen to the auditory inputs. On the other hand, both the general space carrel and the multimedium carrel would accustom the student to a period of independent activity each day separated from the other students and inputs from them. In this latter learning experience they would probably be equally effective, and in the first grade this type of effectiveness would probably be more important than the other. The difference in cost of the two sorts of carrels is great. In calculating the costs of the carrels, the following considerations must be included: The purchase cost of each carrel and the rate at which it must be depreciated. The number of carrels for each classroom of 30 students; this might be either five carrels (each student spending one hour out of the six hours in the school day in a carrel) or ten carrels (which would permit each student to spend two hours a day.) Maintenance costs of the carrels. Costs of supplies and equipment used in the carrels. Maintenance of equipment used in the carrels. Payment for extra time of teacher aides for using the carrels and supervising students in them. Even with extra equipment in the general space carrel, the average cost per student hour in each carrel if there are five carrels per room would be 25 cents in the general space carrel but at least $1.25 per hour in a multimedium carrel. In a school that has 300 first grade students the difference in cost would be $7,500 a year for the general space carrels versus $37,500 a year for the multimedium carrels. The costs of the latter would be far too great for the benefits obtained, so the former must be chosen. This is particularly true since adding these carrels would relieve no teacher time. It would simply improve the quality of education of the underprivileged children who had not been used to solitary activity before coming to school. By the time the pupils got to third grade, the amount of individualized instruction that could be obtained from a multimedium carrel and the saving in teacher time might well be enough to justify the relatively high expenditure for such carrels.

(b) A school system. This particular school system has already installed a closed-circuit television system connecting all of its high schools. It now is trying to decide whether or not to buy video tape-recording equipment. The purposes and benefits which it expects such equipment to achieve are as follows: (a) To be able to develop special instructional programs that can be reused at various times of the day or week for different sections of the same class as well as in subsequent years. (b) To be able to use in the training of teachers video recordings of student-teachers operating in classes and of experienced teachers operating in classes. (c) To be able to produce for commerical television special public service programs about the school system. (d) To increase the student-teacher ratio in some courses by having classes given by video tape lectures rather than by live teachers.

Among the alternative procedures to be considered are live teaching in traditional classrooms and moving pictures.

The costs of this proposed innovation include the money expended to buy the new equipment; teacher time used in learning to use the new medium and in taping materials; as well as lowered morale of those in the teaching staff who oppose the new procedure.

An analysis of cost-effectiveness ratios relevant to the decision to introduce the tape recorder is shown in Table 11.

For the video tape-recording system, we assume that the probability ($P_i$) of it being accepted is about 50-50 (.5). This is determined by the school system management that makes the decisions whether to purchase the equipment, usually based primarily on attitudes of the teachers. Compared to movies or live teaching, its utility ($U_i$) may be rated relatively high (10) because of its convenience to the teachers. Its cost will be $10,000, and so $C_i$ in the equation is 10,000. This is the cost-effectiveness measure for the teacher and we will add to it a cost-effectiveness measure to the students based on the same formula, as follows: To the students it may not

Faculty

Students

$$E = \sum \frac{P_i \times U_i}{C_i} \qquad E_i = \frac{P_{fac,i} \times U_{fac,i}}{C_i} + \frac{P_{stu,i} \times U_{stu,i}}{C_i}$$

$$E_{vtr} = \frac{.5 \times 10}{4,000} + \frac{.5 \times 2}{4,000} = 15:10,000$$

$$E_{live} = \frac{.9 \times 50}{10,000} + \frac{.9 \times 10}{10,000} = 13.5:10,000$$

$$E_{film} = \frac{.1 \times 5}{2,000} + \frac{.1 \times 20}{2,000} = 12.5:10,000$$

$E_{vtr}$ = effectiveness of video tape recorder

$E_{live}$ = effectiveness of live teaching in traditional classrooms

$E_{film}$ = effectiveness of moving pictures

Table 11. Cost-Effectiveness Evaluation About Use of Tape Recorder

seem especially helpful compared to live teaching, so its utility to them is relatively low (2). The price is $4,000 for the year, which is the cost of the machine plus some technician time to operate it. It is an identical cost for teachers and students because it is the same equipment for both of them. The live performance on the television has a much higher probability of being effective (.9). The cost of $10,000 is the same in both cases, and high, because one or more live persons must be involved. It is highly acceptable to the teachers because they do less work than if they prepare television tapes (50). The students like to participate in a live professional teaching performance, so their rating is 10.

The moving picture has the lowest probability of success (.1) because it is difficult to find films that will do the job. On the other hand, films, when they are available, are cheap ($2,000). For the teachers the film has a low utility because they have to choose the film, load the projector, and show the picture. The students prefer films over black and white television because they like the color and the high quality of production. They find there is generally better entertainment value in films than in television broadcasts (20). Finally, looking at the cost-effectiveness ratios, the decision is to invest in the video tape recorder.

Obviously the alternatives are close enough that other factors might decide. If a grant were offered to create a film library, so that the operating budget did not need to support it, that would swing the decision to moving pictures. On the other hand, if some of the best teachers enjoyed live teaching so much that they would leave if taped television or moving pictures were used, the wisest decision might be to raise the teachers' salaries and forget the video tape-recorder.

(c) A university. A private university over a period of 15 years had grown from 4,000 to 15,000 students. Most of the buildings used by the College of Arts and Sciences had been designed before this period of rapid growth. They had been built an average of 44 years before. A few large classrooms in the buildings could accommodate a maximum of 80 students but most of them could accommodate no more than 40 students. Small classes had been universal at the university until ten years before. It now became clear to the administration that if tuition were to be kept low enough that most of their applicants could afford it, they would need to raise the student-faculty ratio and have larger classes. Two alternatives were considered: (a) To build a new building including two classrooms capable of holding up to 500 students each, at a total cost of $2,500,000, or (b) To install closed-circuit television in all the buildings of the College of Arts and Sciences.

The goals which the college's president wished to accomplish were: (a) To increase the student-faculty ratio from 20 to 1, to 28 to 1, in order to keep tuitions down within a range students could afford. (b) To maintain or improve the quality of instruction as reflected by students' performance on various tests. (c) To minimize expenditures for capital construction and equipment.

The cost of the new building had been set at $2,500,000. Of this $1,000,000 was available in cash and the rest could be obtained from long-term loans from the World Bank or the United States Export-Import Bank. The building could be depreciated over at least 50 years. Maintenance costs for the building would be $9,000 a year. With interest charges included, the cost per year for the building would be $88,000.

A closed-circuit television system for all the buildings in the College of Arts and Sciences would have the following costs: Laying of television cables between all the buildings, $83,000; interconnecting all rooms with television cables and installing black-and-white television monitors in each room, $680,000; television studio, tape banks, and tape recorders, $128,000. Total $891,000. This cost could reasonably be depreciated over at least a 20-year period, so the cost per year would be $45,000.

Research on live as compared to televised instruction suggests that students like televised instruction less but that it is not less effective. Use of televised instruction would make possible an average student-faculty ratio of 35 to 1, so that if the college were to achieve an overall 28 to 1 ratio, one quarter of the faculty time could be devoted to small group discussions and individual conferences as a result of savings by using closed-circuit television. This would also be true if large classrooms were used.

For a time it appeared that the nature of loans available meant that the administration could obtain capital funds but not equipment funds. Finally an agreement was reached, however, whereby the money could be used for either purpose. The management decision was then made to install the closed-circuit television. At the same time that this decision was made, the hiring rate of all departments in the college was slowed down over a four-year period so that gradually over that time the college would increase from its former 20 to 1 to the desired 28 to 1 student-faculty ratio. Costs were cut significantly and there was no clear indication that the effectiveness of education suffered. It might even have been improved. At the very least, tuition rates were kept down in an inflationary period.

The above three fictional examples indicate that rational cost-effectiveness analyses of educational systems are currently possible, even if the ultimate decision by the system's decider subsystem is political in nature, taking other considerations into account, as it should. The examples also illustrate the weaknesses of the present state of the art, particularly the difficulties in providing rigorous quantification of the effectiveness of system outputs. To this whole issue the design of the proposed project addresses itself.

Phase I (2 years). The following major methodological issues will be studied in this project with the purpose of developing specific procedures and instruments to deal with them in evaluating educational programs:

- Methods for setting explicit objectives (purposes and goals) of educational programs. Numerous approaches to this problem exist, some mentioned above. These will be compared in an effort to produce a standard methodology.

- Methods for measuring inputs or costs. These include various sorts of matter-energy, personnel, information, money, and time. Both capital and operating inputs must be considered. Many sophisticated and useful measures of monetary costs have been developed, but they are not enough. No single measure of inputs is adequate since the various kinds of inputs differ so greatly.

- Methods for developing agreement on what are the main subsystems or components which all organizational systems, and in particular all educational systems, have in common. Above (see page 37 ) we have proposed a list of such subsystems. Others have suggested other lists. An effort will be made to achieve general agreement of experts on this issue.

- Methods for measuring the important variables in the processes of each subsystem or component of an educational system. This is much more complex than simply testing students on their progress or providing other internal feedbacks.

- Methods for measuring outputs--quality or effectiveness. As we have indicated, this field is much less advanced than the measurement of inputs. Since outputs of educational systems are complex and vary along many dimensions, no single measure of them is adequate. Measures must be taken not only at the time of output (as when students graduate) but also later--measures of the impact of the outputs on the environment, on the suprasystem of which the educational system is a part.

- Methods of determining whether the educational system is meeting its objectives (purposes and goals) with optimal cost-effectiveness.

- Methods of identifying pathologies in subsystems or components which are decreasing the system's cost-effectiveness.

- Methods of treating pathological situations in an educational system, by such means as changing the structure of the system, altering its processes, or incorporating the use of prostheses, such as instructional technologies.

- Methods of measuring the cost-effectiveness of systems of instructional technology from an engineering point of view.

- Methods of using computer simulations to evaluate and improve educational cost-effectiveness.

- Methods of reducing resistances to educational innovation and diminishing their threat to the persons involved.

- Methods of measuring cultural, social, and ethnic variables relevant to the evaluation of the educational process.

Phase II (2 years). The evaluation methods devised would be applied to a range of different educational systems in several less developed countries to see if they are satisfactory. Modifications would be made in the light of these trials.

Phase III (1 year). A book describing the new evaluation methods and their application to less developed countries would be written. Also conferences and short courses would be presented in the United States and in less developed countries, to train educators, researchers, and other specialists to use the methods.

1.5 Staffing and scheduling. The professional personnel required for this project will include a director and associate director, one of whom should be an educator with practical experience and the other a behavioral scientist skilled in quantitative method, and a staff of five other professionals. Consultants in other fields would also be employed as needed.

Secretarial, clerical, and data analysis services would also be required.

The time schedule of this project has been stated above:

Phase I, developing new methods, 2 years.

Phase II, testing methods in less developed countries and modifying them, 2 years.

Phase III, preparing a book, holding conferences, and giving courses on evaluation methodology, 1 year.

1.6 Steps required to translate findings into operational use. Preparation of a book, conducting of conferences and courses, as indicated above.

1.7 Coordination with other research and development work. As indicated above, this methodological research is propaedeutic to practical evaluation of many ongoing and proposed educational programs. At present, if educational evaluation is being done, it is carried out much less satisfactorily than would be possible if new methods could be worked out and tested. The results of this project could affect many other projects proposed below.

1.8 Professional expertise required. An educator with practical experience, a behavioral scientist skilled in quantitative method, an economist, a systems analyst, an expert in instructional technology, an expert in computer simulations, an anthropologist, and consultants in other relevant fields.

1.9 Estimated costs. Estimated amount of labor for this study is 10 man-years a year for 5 years, or 50 man-years. This includes full-time and part-time professional, data analysis, secretarial, and clerical personnel, and consultants.

| | | |
|---|---|---|
| Phase I | 240 man-months | $ 480,000 |
| Phase II | 240 man-months | 480,000 |
| Phase III | 120 man-months | 240,000 |
| TOTAL | 600 man-months | $1,200,000 |

1.10 Appropriate countries for project. The scientific and professional sophistication, the libraries, and the other facilities required if this project is to achieve its goals are more readily available in the United States than anywhere else, so that location seems best for the main effort. Application of the methods in Phase II could be carried out in any established or less developed country. So could the conferences and seminars in Phase III.

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## 2. Proposed Project 2, Priority A

## COMPARATIVE COST-EFFECTIVENESS OF EDUCATION WITH TV, RADIO, AND TRADITIONAL METHODS EITHER WITH TEACHERS OR WITH PARAPROFESSIONALS

This is a study comparing the cost-effectiveness of (a) TV, (b) radio, (c) traditional instruction with teachers, and (d) traditional instruction with paraprofessionals, in formal and nonformal education.

2.1 Objectives. At the top of the list of the most popular alternative media for education in less developed countries are the four mentioned above. Traditional instruction with teachers would undoubtedly have been the almost unanimous choice were it not for the fact that in many such countries there are woefully inadequate supplies of trained teachers. In some relatively poor countries with rapid population growth the percentage of teachers who do not even have minimally adequate training has in recent years increased rather than decreased. It takes years to train teachers, so such trends cannot be altered quickly. Consequently nonjourneymen teachers --paraprofessionals--are doing much of the classroom teaching. They get lower salaries, so the cost of their teaching is less, but its effectiveness may well also be less.

In recent years serious attention has been turned in many countries to mass education by TV and by radio (see pages 166 to 194) as alternatives or adjuncts to traditional modes of instruction. Some believe the cost-effectiveness of radio or TV may be greater, but there have been few if any large scale, well controlled comparisons of these media for formal or nonformal education. That is the objective of this proposed project.

2.2 Levels and subsystem or subsystems involved in this study. The levels are the organization and the society. The subsystems are the transmitter, channel, and receiver components of the channel and net subsystem, and the associator.

2.3 Existing relevant research. There has been much basic research on the teaching process, carried out by trained teachers as well as various sorts of paraprofessionals, including incompletely trained teachers and older students employing various methods of group control and behavior modification. There has also been much basic research on learning by radio and TV. Some of these investigations we refer to elsewhere in this report.

Despite a large research literature on these topics there have been few if any comparative investigations of the cost-effectiveness of the four most commonly used modes of instruction which are the topics of this proposed project. Perhaps the closest large-scale project to the one we propose is the terrestrial experiment of project SACI recently begun in the State of Rio Grande do Norte in Brazil.[1] This is conceived of as a preliminary test of how to use satellite technology for central educational broadcasting, using a balance of television and radio to upgrade classroom instruction and teachers, and to improve learning as a function of different broadcast media.

The terrestrial experiment began in October, 1972, and is scheduled to last for approximately four years. Initially, the transmissions are being made to schools in the state by VHF and medium wave methods using three radio and two TV stations.

Six hundred schools have been selected to participate in the experiment, and an attempt will be made to improve the first four years of primary education through in-service education of teachers and paraprofessionals, as well as courses for students. The schools being used in the experiment were selected at random, falling into three types, elementary school, elementary united school, and elementary isolated school. Equal numbers of each type will receive: (a) TV, (b) radio, (c) TV and radio; and (d) traditional education, chiefly from incompletely trained teachers.

The experiment will have annual phases, in each year emphasizing a different sort of training. The major thrust of the first year is training supervisors and upgrading teachers, showing both how to work with media to improve learning. Up to two hours of TV and one or more hours of radio programs are provided each day, providing in-service education in the Portuguese language, social studies, health and natural sciences, mathematics, civics and moral education, and pedagogy and didactic procedures. While in-service education continues, in the remaining three years there will be a shift to student instruction in different content areas.

The general design of this Brazilian study is like the one we propose here, except that one joint medium (TV and radio) is used in their study and they do not compare traditional education by teachers with traditional education by paraprofessionals.

2.4 The research design. This study would be conducted in a single less developed country which is trying to develop long range policy as to which modes of primary school instruction it shall use.

Phase I, two years. A minimum of six hundred urban and rural first grade classes would be selected for the research sample. Half would be taught by trained teachers and half by paraprofessionals. One-third of the teacher-taught classes, randomly selected, would receive TV instruction in addition; one-third of them would receive radio instruction in addition; and one-third would be taught as in the past. A similar random division into thirds would be made of the paraprofessional-taught classes. TV or radio receivers with the necessary power supplies would be installed in the classrooms selected for such instruction. Those teachers or paraprofessionals who were to teach with these mass media would receive special training to do so.

Curricular materials for the various modes of instruction would be prepared, covering the same subject-matter, that of the first and second grades. The radio and TV broadcasts would be taped in the people's language by studio teachers or actors who had received special instruction in broadcast teaching methods. Formative evaluation would be applied to these broadcasts by testing them with sample classes after they were made.

Similar materials would be prepared for nonformal adult education covering similar subject-matter. Formative evaluation would also be applied to these as they were in preparation. These TV and radio materials, however, would be planned for teaching adults alone and in groups, without the assistance or intervention of trained teachers or paraprofessionals. It would be expected that ordinarily the adults would gather in nearby schoolrooms equipped with TV or radio receivers for instruction in the late afternoon or evening when children were not in the classrooms.

Testing materials keyed to the instruction would be prepared for comparative summative evaluation of each of the modes of instruction, using pretests, tests during training, and post-tests.

Careful cost records would be kept.

Phase II, two years. The various kinds of instruction and summative evaluation tests would be given during these two years to the entire population of students in both the formal and the nonformal educational programs. Careful records of all costs would be kept.

Phase III, one year. The cost-effectiveness data for the various modes of instruction would be analyzed. A follow-up survey would be made of the participation of the various sets of students in the society a year after the instruction ended. A final report would be written, including recommendations for future long-range educational policy in the host nation.

2.5 Staffing and scheduling. To do this important study right would require a large staff. It is hard to make specific estimates of manpower needs because they would depend on what professionals were available in the country.

The project would need a director and associate director trained in instructional technology, curricular planners, test developers, data analysts, translators, TV and radio production staffs, communications engineers, TV and radio technicians and repairmen, and drivers.

The project would last five years, being carried out in three phases:

1. Phase I, two years. Recruiting, planning, preparing the software and hardware, selecting the schools to participate.

2. Phase II, two years. Carrying out the instruction and collecting data for its evaluation.

3. Phase III, one year. Completing the evaluation, analyzing the data, finishing the final report, and taking steps to implement it.

2.6 Steps required to translate findings into operational use. The educators and officials of the host country should receive frequent progress reports. When the final report has been prepared, its recommendations should be discussed informally with them before it is published. If one of the media appears most cost-effective for that country its future use could be planned and then, on the decision of the authorities, experimental instruction with that medium could be systematically expanded to students at other levels and in other locations.

2.7 Coordination with other research and development work. Obviously the ongoing research mentioned in Section 2.3 above is relevant. So are the evaluation methods mentioned in Project 1, which can be applied in this project. Several projects proposed in this report are comparative cost-effectiveness studies, and consequently related to this one.

2.8 Professional expertise required. A large number of different specialties are required to carry out properly such a large project as this. Some of these people, like teachers, radio or TV actors, or electronic repairmen, could come from the host country. Others, like instructional technologists, radio and TV producers, engineers, technologists, data analysts, and educational evaluators would probably have to come from an established country like the United States.

2.9 Estimated costs. It is impossible to make more than very general order-of-magnitude estimates of the manpower effort and money required for such a large project without a detailed study of the needs and resources of the particular country in which it would be carried out. Besides the teachers and paraprofessionals at least 50 and perhaps 100 or more persons would be needed, mostly local citizens. The personnel costs for the project would probably be at least $1,000,000 a year.

TV and radio studios might already be available, but if they had to be built they would probably cost at least $200,000. For the experiment 200 TV receivers and 200 radio receivers plus replacements and spare parts would be needed. At $125 per TV set and $25 per radio (including power source), this would be at least $30,000, probably nearer $40,000. For the entire five year duration of the project the total budget might be nearly $6,000,000.

2.10 Appropriate countries for project. Ethiopia, Nigeria, or Venezuela.

## Reference

1. Polcyn, K. A. Status of communication satellite technology: the next five years in prospective for educators. (Paper presented at the Education Development Institute sponsored by the World Bank, Washington, D. C. 18 Oct 1972.) Washington, D. C.: Academy for Educational Development, 1972. (Unpublished mimeograph, in press), 10-11.

## 3. Proposed Project 3, Priority A

## COMPARATIVE COST-EFFECTIVENESS OF TERRESTRIAL, CELESTIAL, AND MIXED COMMUNICATION CHANNELS, AND TRADITIONAL EDUCATION

This is an operations analysis of three countries of the cost-effectiveness of (a) terrestrial (cable or microwave or transported audio or TV tapes); (b) celestial (satellite or high-flying plane); (c) mixed terrestrial-celestial educational communication channels; and (d) traditional education.

3.1 Objectives. A major increase in cost-effectiveness of education may perhaps be achieved by using media that depend on transmission of electronic signals over networks which may cover hundreds or thousands of miles. Included are such media as audio and video programs (with and without feedbacks from students to the studio teacher); CAI and CMI by remote terminals which can address a central large computer; and others. These are costly media unless they can reach a very large population, and to do that a large network is required. If a less developed country is to make the major decision to use such an educational medium on a large scale, it wants first to have a plan which assures that the costs are minimized and the engineering effectiveness (see page 280) is maximized. To make such plans for three different less developed countries is the objective of this project. Alternative calculations will be made for three sorts of electronic channels or nets, and their cost-effectiveness will be compared with that of traditional classroom instruction in each of the three countries.

The electronic channels and nets studied will be:

(a) Terrestrial--underground cable or aboveground microwave (both of which are subject to various kinds of physical damage, including sabotage or vandalism, which are serious threats in some parts of the world); or transport of audio or TV tapes (which becomes expensive if they must be distributed to many locations, especially if the means of transport are unreliable).

(b) Celestial--satellite (which is very costly to build and put in orbit) or high-flying plane (which is cheaper but covers less area than a satellite although much more than a TV station).

(c) Mixed terrestrial-celestial systems.

3.2 Levels and subsystem or subsystems involved in this study. The organization and the society are the levels under consideration. All three components of the channel and net subsystem are considered.

3.3 Existing relevant research. The sort of effectiveness dealt with in this project, engineering effectiveness, can be measured much more precisely than educational effectiveness. Mitchell has been developing a class of computer models which can be used to make cost-effectiveness comparisons of alternative electronic network configurations for any country for which the necessary input data can be obtained.[1] This project would draw heavily on such research.

3.4 The research design. First three geographically large, less developed countries would be selected which need extensive educational development--like Brazil, India, and the Philippines. Engineers would then be sent to each country to obtain details of the geography, topography, and present electronic channels in use. The many hundreds of widely dispersed Philippine islands, of course, constitute a much different terrain than the solid land masses of India and Brazil.

The data collected by the engineers would be input to computer models designed for the purpose. So would current cost data for the various necessary types of hardware for the alternative systems--costs which the particular country with its particular manufacturing ability would have to pay. The alternative cost-effectiveness (in terms of costs per student hour of excellent quality reception) would then be calculated by computer. This would be compared with data available from each country about costs per student hour for traditional education. (Since this project is not concerned with educational effectiveness, it would be assumed, probably falsely, that, once an hour's worth of good quality signals reached a student, its educational impact would be identical no matter what medium was used.)

Analyses could be made for one-way and two-way channels, the latter presumably being educationally more effective.

The following sorts of issues must be faced in this project:

- A TV station costs at least $100,000 to set up but its signal reaches only to the horizon.

- A high-flying light plane can circle at about 30,000 feet bearing a 55-pound transponder which can relay two TV signals, or 1,000 audio signals, from a ground studio down to the ground, and 10 audio signals from different points over an area with a diameter of 500 miles, back to the studio. It costs about $2,000,000 to put into operation and $25 an hour to operate.

- A satellite, which can cover a large country like Brazil or India, costs between $10 million and $30 million to build and put into orbit.
- Microwave or cable can cost-effectively reach 95 percent of the population, but it would be very expensive to reach 100 percent by such means, as a satellite can.
- The cost-effectiveness of all these systems except satellites is much less in areas with a high percentage of rural residents as compared to urban.
- Satellites can be counted on to remain in orbit and function for only 7 to 10 years.
- Cable and microwave are easily damaged.

All these considerations must be weighed in making a final decision on a specific channel and net configuration for a country.

3.5 Staffing and scheduling. Two communications engineers and a secretary could complete the necessary data collection and analysis for three less developed countries in one year, if the data were available in those countries.

3.6 Steps required to translate findings into operational use. A report to educational administrators and governmental policy makers in each country, plus discussions between them and the engineers, should be sufficient.

3.7 Coordination with other research and development work. Knowing engineering cost-effectiveness is just the beginning. As we indicated in Project 1 above, these findings must be incorporated with educational evaluations before the optimal educational system can be planned and implementation of it begun.

3.8 Professional expertise required. Communications engineers.

3.9 Estimated costs. Three man-years, or 36 man-months, of human effort. Budget for personnel $72,000, plus $10,000 for travel twice or three times to three countries. Total budget is $82,000.

3.10 Appropriate countries for project. Brazil, India, and the Philippines. These are all large countries which could use a domestic satellite or terrestrial system of their own.

## References

1. Mitchell, C. Determination of the comparative engineering cost-effectiveness of terrestrial, celestial, and mixed terrestrial-celestial instructional technology systems. (Unpublished mimeograph.)

## 4. Proposed Project 4, Priority A

## TV VS. TV WITH AUDIO FEEDBACK

This is a comparison of the cost-effectiveness of (a) TV and (b) TV with audio feedback in formal and nonformal education.

4.1 Objectives. The objective of this project is to test, in a less developed country, the effectiveness of instructional TV with and without an audio feedback system and to derive cost-effectiveness ratios for TV-aided instruction without audio feedback and with three degrees of feedback.

One-way instructional TV has proved an effective method of presenting course material. Often this includes local feedback of a sort given by a teacher who discusses with the students after each lesson the material presented on the TV, answers what questions he can, and provides explanations. In many classroom situations in less developed countries, however, the teacher is not a fully trained professional but is instead a paraprofessional who does not know the subject-matter well and whose ability to provide this feedback in a satisfactory manner is limited. It seems intuitively probable that immediate audio feedback from the teacher in the TV studio, if it could be arranged for, would increase the effectiveness of instructional TV. Findings of learning experiments mentioned in Section 4.3 below also suggest that this sort of feedback would act as a reinforcer of learning. This project is designed to test the hypothesis that the more complete the feedback, the better would be the learning.

4.2 Levels and subsystem or subsystems involved in this study. The levels are the organization and the society. The subsystems are the channel component of the channel and net subsystem and the associator subsystem.

4.3 Existing relevant research. Experimental findings on the relationship of feedback to learning are directly relevant to this project. No learning takes place without feedback.[1] Learning increases in direct proportion to the completeness of the feedback provided. Research in learning theory on reinforcement and motivation is also relevant.[2]

4.4 The research design. This project would be carried out in the school system of a less developed country which already has instructional TV, such as the Philippines, Samoa, or the Ivory Coast.

The TV programs can be broadcast over the air, by cable, by microwave, by a transponder on a high-flying, circling plane, or by satellite. Audio feedback can be provided over a telephone line; by two-way radio, with a transmitter in the school; by a high-flying plane equipped with a transponder; or by the same satellite system that transmits the TV signal. The method used would depend upon what equipment configuration is feasible in the country in which the research is done. In India, which is to have a satellite available for educational use, this might be the method of choice. A satellite has the advantage of a very large total bandwidth. In areas with limited telephone service, a light plane with a transponder might be used. A transponder of this sort can relay 10 audio signals from 10 schools in different locations back to the TV studio, which would be sufficient for this project. Research and development on these various transmission methods has been discussed above (see pages 317 to 320). It would be necessary to add equipment to provide audio feedback from only a quarter of the schools to be used in the project, those in Condition 4 (see below). Since the teachers and students in the project would already be familiar with instructional TV, addition of the audio component would require little special preparation beyond a period of familiarization.

It is proposed that 10 classrooms would be assigned to each of four conditions, a total of 40 conditions. These conditions are:

Condition 1. A one-way video delivery system in which information is presented by the studio TV teacher or actors, but no attempt is made to elicit responses from the students in any way. Of the four alternative systems this involves the student least in the communication process, assigning to him a passive-receptive role.

Condition 2. A one-way video delivery system in which the TV teacher elicits responses by giving directions and asking questions but students have no means for communicating their response to the teacher. These information inputs involve the student enough to keep him alert and somewhat active in the communication process. The TV teacher can provide limited feedback by stating the correct answers after asking the questions, but the teacher receives no immediate feedback on how successfully he is communicating the information to the student.

Condition 3. A one-way video delivery system in which the instructor elicits responses by giving directions and asking questions and the students record their responses by writing or marking on test sheets. They do not receive immediate feedback on the appropriateness of their responses unless the TV teacher later gives the correct answer. The recorded responses, when returned, provide the TV teacher with indications of the success of his presentation and allows him to review or otherwise modify future presentations for increased effectiveness.

Condition 4. A one-way TV, one-way audio system in which the TV teacher can ask students questions in remote classrooms or give them directions and receive feedback from them. This provides an opportunity for the TV teacher to correct student's errors, reinforce their desirable responses, and directly motivate them. In addition it allows the students to influence to some degree the pacing of the instruction by providing the TV teacher with continuing feedbacks as to how well his presentation's instructional objectives are being met.

The course materials employed in this project should be such that how well students do on them can be objectively measured. Tests would be given to students before the course began, at monthly intervals during it, and at the end. Differences in average test performance over time would give one measure of instructional effectiveness. Cost measures would include all instructional costs such as teachers' salaries, costs of TV programs and transmission, and costs of the audio feedback system. From these measures a cost-effectiveness ratio could be calculated. Other measures could also be made.

4.5 Staffing and scheduling. Operational staff besides those employed for the regular instructional TV and classroom programs and for whatever communications channels were used for them would be required only in Condition 4, in the audio feedback condition. A communications engineer and maintenance personnel would be needed for that condition of the project. The project staff would also need a director, an associate director, a data analyst, and a secretary.

Phase I, six months, would be devoted to planning and recruitment. Also the curricula would be selected and the schools and classrooms chosen. Furthermore, the equipment would be obtained and installed.

Phase II, one year. The project proper.

Phase III, six months. Data analysis and final report.

4.6 Steps required to translate findings into operational use. If the audio feedback were found to increase cost-effectiveness, it would be desirable to add audio feedback equipment to all classrooms in the already existing TV instructional system. Also wide publicity should be given to the findings within the host country and elsewhere.

4.7 Coordination with other research and development work. This should be coordinated with other researches that measured cost-effectiveness of instructional systems. Its findings might advance learning theory because of its pertinence to reinforcement, motivation, and feedback.

4.8 Professional expertise required. Either the project director or the associate director should be an expert on TV instruction. The other should probably be an economist or educator interested in cost-effectiveness evaluation. Appropriate engineering and statistical assistance would be needed. Also a secretary and electronic maintenance personnel.

4.9 Estimated costs. A total of 11.5 man-years in addition to the time of all operations personnel would be required during the two years of this project. The costs:

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| 1. Phase I, six months | 36 man-months | $ 72,000 |
| 2. Phase II, one year | 72 man-months | 144,000 |
| 3. Phase III, six months | 30 man-months | 60,000 |
| TOTAL | 138 man-months | $276,000 |
| | Equipment | 25,000 |
| GRAND TOTAL | | $301,000 |

4.10 Appropriate countries for project. The Philippines, Samoa, and the Ivory Coast, because they all have ongoing instructional TV programs.

## References

1. Cf. Gagné, R. M. & Rohwer, W. D., Jr. Instructional psychology. Ann. Rev. Psych., 1969, 20, 398-401.
2. Miller, N. E. Liberalization of basic S-R concepts: extensions to conflict behavior, motivation, and social learning. In S. Koch (Ed.). Psychology: a study of a science. Vol. 2. N.Y.: McGraw-Hill, 1959, 256-272.

## 5. Proposed Project 5, Priority A

## RAISING PROPORTIONS OF EDUCATIONAL BUDGETS FOR ITEMS WHICH INCREASE COST-EFFECTIVENESS

This is a management study of ways to lower the proportion of expenditures which do not increase educational cost-effectiveness of formal and nonformal education, and raise the proportion which do.

5.1 Objectives. This study would have the objective of analyzing the budgetary and other problems of a less developed country in order to suggest ways in which greater educational cost-effectiveness could be achieved.

Many less developed countries are experiencing increased demand for both formal and nonformal education at a time when other demands upon the national budget are also great. Their populations want improved housing, better roads, good health, social security, better employment opportunities, and the opportunity to secure the luxuries and conveniences of modern life, of which they are becoming aware. In short, they hope to move simultaneously in several ways to improve the quality of their lives.

The situation in education is compounded by growing populations and by the increasing percentage of young people who wish to complete the higher grades in school. In many countries the population increase is not a temporary crisis. A United Nations analysis projects significant increases in population throughout the world, with some of the greatest increases expected to take place in the less developed countries.[1] For example, Mexico, with a population of 50,710,000 in 1970, is expected to increase to

84,431,000 by 1985. Brazil, in the same time, is expected to increase from 93,029,000 to 142,564,000. The figures for South Vietnam are from 17,952,000 to 23,900,000; for Chile 9,780,000 to 13,609,000; and so forth. In every one of the 35 countries on the list, also, large increases in urbanization are expected, along with almost certain rises in demands for improvements in the quality of life.

One of the major results of this growth is that many additional places are needed where students can study. This faces education policy makers with a dilemma as to how funds should be spent. This is a good example of the basic issue faced by this project--how to spend more of the educational budget on raising cost-effectiveness. Educational planners all too frequently devote a disproportionate amount of the funds available for education to construction of new school buildings. This is funded by tax revenues, by issuing bonds, by foreign aid grants or loans from other countries, or by borrowing from international banks. These arrangements involve long-term financial commitments which make major inroads on educational budgets. Such expenditures seem entirely reasonable to many policy makers and citizens, since many schools have only one room, no running water or toilets, no electricity, and no blackboards. What is more, fine new buildings give proof that politicians are benefitting the people. They are a source of civic pride. The people often use them as community centers as well as schools and places for nonformal education. Consequently they approve of their construction. Unfortunately, this approach virtually assures that within the new buildings badly trained and poorly paid teachers will work with insufficient and inadequate teaching materials.

Spending a high proportion of funds on the matter-energy processing subsystems of the educational organization so that there is no money to support adequately the information processing subsystems, which carry out the fundamental functions of the educational system, has unfortunate consequences. The students who are supposed to benefit from the modernization program may study in better physical surroundings, but they receive no more or better education in the new buildings than they did before. It may even be worse. Funds, as it were, are spent on the "skeleton" of the school and its "nervous system" is neglected.

There must be better ways to operate educational systems, and the chief objective of this study is to search for alternative ways of solving the complex educational problems of these countries.

5.2 Levels and subsystem or subsystems involved in this study. The levels are the organization and the society. The subsystems include parts of two matter-energy processing subsystems, components of the producer that build and repair educational buildings, as well as of the supporter that maintain the buildings. Included also are several information processing subsystems, the transmitter; the channel and receiver components of the channel and net; the associator; the memory; and the decider.

5.3 Existing relevant research. There appear to be no research findings that are relevant to this project. There is much practical experience, of course, in constructing and funding school buildings. There has also been innovative work on more cost-effective designs for school buildings.

5.4 The research design. This study could be conducted only with the full and affirmative cooperation, and hopefully initiative, of the host government. It would last two years and be carried out in three phases:

Phase I, one year. A study of the national, state, and local financial situation to determine what funds are available for education and how they are spent for various programs. How much goes to building construction? How much to payment of interest and repayment of capital on loans? Does all this represent a reasonable allocation of expenditures?

Also an analysis of the whole budget might be carried out to discover what adjustments might reasonably be made to include provision for improving education without neglecting other important governmental commitments of the government.

Other facts that might contribute to an understanding of the country would also be studied. Some of these would be the climate throughout the year; the typical daily schedule of the people--hours of work, daily rest periods, meal times, time devoted to recreation; and schedule differences in urban and rural areas, and how rural schedules change during planting and harvest times.

Phase II, six months. In this phase of the research, a commission of foreign and local consultants, local educational planners, and local governmental officials would consider alternative plans that might provide education in suitable surroundings more cost-effectively. The commission would include economists, planners, educational architects, educators, experts in educational technology, budgeteers, and so forth. Innovative thinkers would be explicitly sought out to serve on the committee.

This commission would be given analyses of the facts about the country obtained during Phase I, projections of its budget over the next several years, and information on current plans and commitments already made for the future. They would also have described to them significant aspects of culture and attitudes that would affect the response of the people to changes in the educational system.

The work of the commission could then be carried on with conferences, brain-storming sessions, subcommittee meetings, and talks by experts on particular aspects of the situation.

Innovative approaches by participants would be encouraged, in considering what appropriate learning environments for students could and should be, how costs for them could be cut, and how education could be made more cost-effective. Could architectural innovations provide the required amount of shelter and suitable working surroundings more cost-effectively than traditional buildings? In warm climates with little need of protection from the elements might a building program reasonably be made secondary to upgrading the instruction offered? Could small buildings that contained basic facilities for sanitation, provision of food, electrical facilities, and storage be built first--perhaps in factories--and less solid shelters be used for other activities? Are any other new, cheap, architectural approaches applicable? Are other buildings in the community suitable for use also as classrooms? Are assembled classes necessary for all courses or could many students work individually, on some days, perhaps at home, with various media and scheduled group instruction on others? Could half-day shifts be used?

What other scheduling changes over the day and year could be made to increase use of existing facilities? If the school building is also to be a community center, could building expense and maintenance be shared with some other part of the government? What use could be made of paraprofessional teachers? Could local residents be given more responsibility for planning in their own towns? Could they build schools on a voluntary basis?

These are only a small sample of the sorts of questions to be discussed with reference to the culture, needs, existing conditions, hopes for the future, and budget of the host country. This phase of the study would produce one or more plans for the educational system of the country. A report would be written and presented to the relevant governmental bodies or officials, who would be requested to select a final plan.

Phase III, six months. In these final months a program would be developed for publicizing and gaining citizen support for the final plan, if the government chose one. This might include arranging public meetings, discussions with local citizens and political officials, parents' meetings, broadcasts, newspaper coverage, or other means of achieving the desired result.

5.5 Staffing and scheduling.

Phase I, one year. A project director who was an expert in public finance, national budgeting, and data analysis, with an associate director, a secretary, and consultants, could carry out Phase I.

In Phase II, six months, the commission would come together in many meetings and their report would be written.

In Phase III, six months, the public relations planning and campaign would require the services of consultants on the relevant content matter and others skilled in developing such programs.

All personnel, except probably some consultants, could be citizens of the host country.

5.6 Steps required to translate findings into operational use. These would depend upon the findings of the commission. Whatever building programs, ventures into educational innovation, or other activities were decided would have to be undertaken. Public support would be elicited.

5.7 Coordination with other research and development work. This project would take advantage of all current and past work on educational innovations.

5.8 Professional expertise required. A wide range of skills would be needed: For the project director, as noted above, financial analysis and budgeting; for consultants, architecture, planning, education, educational technology, and other fields.

5.9 Estimated costs. The total human effort on the project would be 9.5 man-years in addition to the time spent by citizens, educators, and officials of the host country.

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| 1. | Phase I, one year | 48 man-months | $ 96,000 |
| 2. | Phase II, six months | 30 man-months | 60,000 |
| 3. | Phase III, six months | 24 man-months | 48,000 |
| | TOTAL | 102 man-months | $204,000 |

5.10 Appropriate countries for research. Brazil, Vietnam, and Iran. All of these countries have much educational construction or reconstruction to do.

## References

1. Anon. As cidades: um dia sera preciso dizer "lotadas"? *Realidade*, 1972, 7(74), 211-212.

## 6. Proposed Project 6, Priority A

## COMPUTERIZED EDUCATIONAL INFORMATION SYSTEM

This is a study of how to improve educational planning and management by use of computerized planning and management information systems.

6.1 Objectives. Many educational systems in less developed countries carry on in great ignorance of their own operations. They collect pitifully few or no data relevant to planning and management, and consequently decisions about them must be made without adequate information. This almost certainly means that the cost-effectiveness of the system is much lower than it would be if the decision makers had more facts available to them. This is now possible because much attention in the last 10 years has been devoted to the creation of computerized planning and management information systems for educational institutions of various sorts, primarily in the United States and Canada. The chief objective of this study, therefore, is to draw from this background of work the knowledge necessary to produce such a system designed especially to improve planning and management of the educational activities of the less developed countries.

This would be a comprehensive, integrated administrative data processing system, adaptable to growth and change while continuously providing the data necessary to meet the myriad requirements of a nationwide educational system. Information inputs would be obtained from each participant institution and all the people in it, as well as from the communities of the nation which it serves. One set of outputs would be the reports needed for planning and management. These would be selected as appropriate outputs of a well-designed system and would be presented in formats that appear optimal for the purposes of the administrators that would be the users.

The system would intentionally be such as to minimize uniqueness. Individual programs and whole subsystems or modules would be borrowed from other institutions if they were seen to work well in their original environment and were amenable to incorporation into another system. Programs, however, usually require much additional work and thorough testing in order to be successfully transferred from one institution to another. Obviously this is even more true when they are transported from one nation to another.

6.2 Levels and subsystem or subsystems involved in this study. Organization and society levels. The computerized information system would be a prosthesis almost wholly for the decider subsystem, although it would collect and disseminate information from and to most or all parts of the educational system.

6.3 Existing relevant research. In our literature review for Project 1 (see page 270) we referred briefly to a category of research directly relevant to this project. It is now important to find out in more depth what a computerized information system is (often called MIS, for "management information system"). How can it be used by educational institutions? What research and development has been done on this? We cannot provide a better summary of this field than the one Bogard wrote for the Carnegie Commission on Higher Education. It is directed toward higher education in the United States, but the principles are equally applicable to a school system in a less developed country. Bogard states:[1]

"Computerized management information systems,...are a comparatively recent development. Whether the complexities of modern organizations brought about computerized systems or whether the systems permitted modern organizations to attain their current complexity is impossible to determine. In either event, it appears that computerized management information systems have become an integral part of most complex business, industrial, and governmental organizations.

"But what is an MIS? Harold Sackman, a proponent of computer science, defines an MIS as:

'An evolving organization of people, computers, and other equipment, including associated communications and support systems, and their integrated operation to regulate and control selected environmental events to achieve systems objectives.'

"College and university administrators are understandably hesitant about the usefulness of such a system. If, however, an MIS is defined in terms of its purpose, or need, the benefit of such a system becomes more readily apparent. An MIS for an institution of higher education should meet three basic needs:

'1. It must provide administrators with information about the day-to-day operations of the university.

'2. It must provide the information needed to develop the planning capability required for both long- and short-term planning by means of analytic techniques.

'3. It must provide the reporting capabilities required by the societal and economic pressures for accountability.'

"Even more simply, management information systems provide for the systematic collection and use of data and for accurate feedback to the administrator of the effects of an institution's current or proposed operations.

"Management information systems need not of themselves be complex. It is the extent and diversity of information required that lead to their complexity. Hence those administrators who believe that they do indeed have MIS may, from the standpoint of their requirements, be perfectly justified in their belief. Nevertheless, the suspicion remains that many administrators are satisfied with the information received for the simple reason that they are not aware of the need for more, being content instead to deal with the day-to-day problems as they arise on the basis of personal judgement.

"As the importance and cost of higher education increase there is an irresistible pressure that forces planning and decision making up the scale of available organization and, therefore, it is all the more critical that universities participate directly in these operations. But, in order to participate effectively administrators must have information about the operation of their institution that only a modern MIS can provide."

If the decision makers in educational organizations are to make wise use of the information they collect, they must synthesize it in so some way that will assist them. In recent years this has been done by constructing mathematical models of the educational organizations. In a companion paper to that of Bogard quoted above, Bell wrote of such models. He stated:[2]

"They are elaborate calculating procedures that enable administrators to estimate, using simple assumptions about growth of the student body, the numbers of majors there will be in different departments, the numbers of new faculty members that will be needed at different ranks, the numbers of new classrooms and laboratories that will be needed, and so on. The main work of constructing such a model is determination of a large number, literally thousands, of percentages using past data about student flows. Thus the percentages of freshmen in various departments who fail in the first semester and in the second semester, who drop out never to return, who drop out and return later, who return for their sophomore year, who decide to change majors in their first year, and the percentages of those who select the various options for new majors must be determined. One needs similar percentages for other categories of students--sophomores, juniors, seniors, graduate students, transferees, returnees. Given the number of majors in a given department one needs the percentages of students who will take the various courses, who will minor in other departments and take which courses there, who will take which courses in still other departments, and so on. Then one needs percentage distributions of various demands of categories of users for various kinds of facilities.

Finally a host of percentages is needed about utilization of faculty at various levels, about staff support, and about services for health, finances, records of grades and credits, athletics, student loans, food, housing, etc. The fundamental object is to determine course enrollments so that one can calculate needed staff, services, and facilities. The data are programmed for a computer so that the calculations can be done rapidly.

"With such a model university administrators can explore the financial and other implications of various growth, admission, and personnel policies. The model is a tool for assisting administrators to operate the institution more efficiently."

He went on to discuss various strengths and weaknesses of such models. Then he turned to a particular form of model, large-scale models of educational organizations:[3]

"Simulation is a popular and powerful modeling tool. With the assistance of a computer to assure computational feasibility, simulation models can be built to forecast the future behavior of an existing system. The predictions often cover a span of years, while the necessary computations require minutes of computer time and weeks of labor.

"It is convenient to list four purposes of simulation that are common to most applications:

"1. To provide an extrapolation into the future. The behavior of an existing system operating under known policies can be simulated to predict future system characteristics. For example, one could quantify current undergraduate admission policies by subject field, could extrapolate from current data on student flow, and could make predictions of, say, the number of sophomore social science majors in the system five years from now.

"2. To provide an experimental tool for forecasting the implications of a variety of policy parameter values. With the above model one could asses the effects of proposed alternative policies, for example, several different admissions quota levels for social science majors.

"3. To provide impetus for "rational" thought about cause and effect relationships. The construction of a model requires careful consideration of the system structure. These demands might lead to new insights for the decision maker.

"4. To provide a computational mechanism for measures of system performance that would otherwise be difficult to calculate. For example, the cost of providing educational services to a sophomore student in social sciences could be estimated.

"While a simulation model can offer these four types of advice, it is important that the advice be worth the cost of preparing it.

"In simulation of educational institutions, the primary purpose is to provide guidance about future resource needs--faculty, physical plant, and supporting activities (for example, university administration, student health service). A mathematical model is used to express the relationship between available university resources and production of educated manpower. Such a model is typically constructed of four phases:

"1. Estimation of future student body mix by age (or length of stay in the university) and major (or more broad field, for example, physical sciences). Simplifying assumptions on student flow are necessary for computational feasibility. Markov Chain techniques are the most common. From this phase emerges a set of statements such as "in 1976 there will be 2,500 sophomore social science majors." These data are the inputs to phase.

"2. Computation of demand for individual courses. Using past data on courses taken by students of given major and experience level, one can estimate the demand for every course in the university. With knowledge that about one-tenth of sophomore social science majors take Anthropology 1, a prediction can be made that there will be about 250 sophomore social science majors demanding Anthropology 1 in 1976. One can make similar estimates for all other major and experience level categories to arrive at an estimate for the total demand for Anthropology 1. The same process can be repeated for all other courses. These enrollment forecasts are inputs to phase three.

"3. Estimation of faculty and space needs. With each course assigned an enrollment estimate, the individual department can then estimate the required classroom and/or laboratory space and the required faculty time invested in the course. Typically, faculty time estimates take rank into consideration. By aggregating all of these computations one arrives at an estimate of total space requirements and faculty needs (FTE by rank). The output of phases one to three is then fed into phase four.

"4. Estimation of support needs. With knowledge of student body size, faculty composition, and classroom requirements, estimates can be made concerning administrative staff, library, food service, student health service, etc.

"Besides the fact that the output of one phase becomes the input of the next, there are other interactions between phases. For example, some graduate students are teaching resources and 'consumers of teaching resources.' Their presence tends to increase both demand and supply for 'educational production.'

"The most ambitious models have been built by Koenig, Judy, and Weathersby....Koenig prefers to consider a set of sectors of a university economy rather than a sequence of computational phases, but we will use the four-phase description given above.

"In Koenig's model, students are divided by level and subject field into disjoint categories....The number of entering students in each category in each time period must be estimated. Of course the possibility of students leaving the system must be incorporated into the model.

"In allocating financial aid resources to departments, university administrators have partial control over student progress and the demand for course work in certain fields. These policy parameters are explicitly taken into account by Koenig's model. He attempts to isolate students affected by financial aids from those who are not."

Koenig's model proceeds to calculate the future student enrollment. From this it calculates the projected demand for various courses and finally the faculty, staff, and facility resources that will be required. Bell continued:[4]

"Judy's CAMPUS model was designed at the University of Toronto for use there and for more general use. Differences between Canadian and American universities make it less suitable for direct use in the United States. However, the notion of a single simulation model readily adaptable to any university is an attractive one. Many administrators might conclude that a simulation model is worth buying but not worth constructing from scratch. Judy's purposes in constructing CAMPUS were to assess the flexibility of the system simulation approach to university problems, determine the availability of required data, investigate the applicability of statistical methods to these data, and determine the various facets of the university system and inherent modeling difficulties. He envisioned four types of questions that the CAMPUS model could help answer: (1) What are the resource implications (faculty, physical plant, and total budget) of particular enrollment projections? This is a direct output of the four simulation phases we have mentioned. (2) What are the resource implications of meeting established goals on educational manpower? In this case the university can control the enrollment in each field. (3) What are the resource implications of particular changes in curriculum? (4) What are the resource implications of general policy changes?

"Missing from all of these simulation models is a fifth vital question: What are the resource implications of external governmental actions, environmental changes, and changes in public tastes? A mechanism for answering such questions is impossible to build into a university system simulation. The resource implications are likely to be much harder to predict for a university--a nonprofit producer of educated manpower--than for a profit-making firm that makes consumer goods. Weathersby has used multiple linear regression techniques to estimate some of the effects of these variables that are beyond direct control of university administrators.

"Weathersby's university cost simulation model is currently being modified by the Western Interstate Commission for Higher Education. Called the Resource Requirement Prediction Model (RRPM), it will be designed for ready applicability to universities in the United States. Although his model is quite similar to the others (in that it generally follows the four phases mentioned), Weathersby points out some of the difficulties encountered in the modeling process.

"Classroom space, for example, is generally assigned as a known function of student body size, student credit hours, or student classroom contact hours. Classroom needs are then easily computed from the model. However, on many campuses, instructional space (classrooms, labs, faculty offices)make up less than 20 percent of the total space in campus buildngs. A crude method must be used to compute the total physical plant budget.

"Nonteaching academics are another problem since their numbers do not hinge so intimately on student enrollment. Weathersby's model uses linear regression techniques to estimate future requirements of nonteaching academic personnel.

"In dividing the university's activities into several disciplines for a cost simulation, there are often organized research activities that cannot be conveniently categoriezed. Examples within the University of California system are a liquid air facility and a pilot secondary school. For the purposes of the model some categorization must be made.

"Levels of campuswide activities such as libraries, residence halls, and administrative overhead are estimated by regression techniques in Weathersby's model. All these difficulties illustrate the fact that the transformations from student enrollment to class credit hours to FTE faculty to office and classroom space prevalent in university simulation models leave a large budgetary slice of university activities undetermined. Levels of these activities must be estimated by other techniques such as multiple linear regression or by simplifying assumptions that relate them to levels of activities determined through the input-output phases of the model."

"Weathersby has tested his model on past Berkeley data and has found it generally successful with errors typically under five percent."

Later Bell wrote:[5]

"In mentioning Koenig, Judy, and Weathersby, we did little justice to the numerous existing simulation models here and abroad. Many others are reviewed by Wurtel. Simulation has been used by UNESCO in modeling the educational development in Asian countries."

In concluding this review of relevant research and development it is important to reiterate that, though it has been oriented chiefly to higher education in the United States, its principles are equally applicable to educational institutions like schools and state or national educational systems in less developed countries.

6.4 The research design.

Phase I, 2 years. First the less developed country and the educational system in it, national, state, or local, would be selected. Then a preliminary investigation would be necessary to establish a basis for a computerized planning and management information system design. It would determine the amount and kind of information currently processed in the organization, comparing existing methods with present needs and those likely to develop in the future. It would be carried out by a team of expert consultants in management information systems from the United States, computer programmers, systems planners, and educational administrators.

Then attention would be turned to the system itself. The first stage is to set goals and objectives identifying all the major purposes and constraints to be satisfied by the system. The list need not be exhaustive. Anything omitted should be on the grounds of triviality, not of sensitivity.

Specification of goals and objectives is a function of the administrators in consultation with all segments of the organization and community. It cannot be delegated completely, but there are strong technical considerations with regard to what goals can be achieved, are desirable, and should be avoided. There is therefore need for joint administrative and technical action, even if the final decisions regarding goals and objectives be regarded as purely managerial.

Specification of goals and objectives would mark the end of the preparatory stage and the end of the fruitful period for direct general management involvement. Work on the particular system actually to be constructed is an assignment for specialists chosen for their individual skills, but with recognition that the skills are to be employed as part of a much larger team effort. The total set of skills runs the gamut from the ability to design user interfaces that encourage appropriate user behavior to recondite techniques for detection and correction of errors in signals moving from one electronic storage medium to another.

Then a set of detailed system requirements covering both the structure and the functions of the proposed system would be prepared. It should include the best alternatives for input, output, processing, storage, and control functions of the whole system and its major subsystems. The major subsystems ordinarily would include on-line, constantly updated data banks on students and alumni, faculty, staff, curriculum, finances, facilities and equipment, libraries, and the organization's environment--the community or society.

Not all parts of the information system would need be developed (or could be developed) at the same time or the same rate. Priorities and input-output relations within and among various subsystems force allocation of effort to different parts of various subsystems at different times. The allocation method must be comprehensive in including all available resources. It must be sensitive in responding to all the needs of its sponsors and constituents. It must be flexible in adapting to changing conditions or new information. It must be adamant in rejecting pressures to adopt expedient or conforming solutions inconsistent with or irrelevant to the goals of the system.

Development of individual subsystems would begin as soon as a preliminary design had been approved. For an information system, development is tantamount to production since there is little opportunity for pretesting techniques or for extended pilot runs with other than the intended final product. The philosophy that development precedes production is important, however, to iron out design deficiencies and to assure that the environment for which the system or subsystem was designed resembles the real environment in which it is to operate. Various postdevelopment and preproduction tests can also be performed to assure that system failures, which are bound to occur, will not be catastrophic in themselves and will not serve as the nucleus for a snowball effect when operating with other systems. All this would take much programming and testing effort.

Phase II, 2 years. Implementation. Introducing a new information system on its users is somewhat like imposing a political system. It can be done if enough power is exerted, but the result is not always quite what was planned, especially if the imposing power withdraws for any reason. It is better to tailor the system to fit the using community and to introduce it in a way that at least allays user fears if it cannot encourage user support.

To accomplish this goal requires extensive preplanning with user participation at every step, although the user must not be allowed to take control. Neither must the system designer be allowed to force any solution upon the user.

Implementation of the information system would include selection of the the computer- terminal- communication link configuration. It also would include individual tests to be applied to separately identifiable subsystems subsystems and integration tests to be applied to their combinations. The planning, if it were to be effective, must also include production of manuals and personnel training, including team training activities that take into account that subsystems of the educational system exist for the convenience of the system not of the individual units. The planning should also take into account the need for parallel processing as part of the test and training regimen.

The design and development process, whether for a whole system or for a major subsystem, does not end with installation. Something is almost certain to have been forgotten or misinterpreted, so that a tune-up period is always required with any but the simplest systems. Even then the task is not complete, for it is only in use that one can tell whether the original goals are being met.

6.5 Staffing and scheduling. It is assumed that computer operators and programmers will be supplied by the host country. They may need special intensive training for this task by visiting consultants. With such an arrangement the chief project staff would be a resident director and an associate director, a chief visiting consultant from the United States experienced in planning and use of planning and management information systems for education, and a dozen or so specialist consultants on specific subsystems or other aspects of the information system. These consultants would be required primarily during Phase I, the planning and design phase. During Phase II, implementation, they would be needed less and less frequently.

6.6 Steps required to translate findings into operational use. These are an integral part of this research and development design and have been outlined in Section 6.4 above.

6.7 Coordination with other research and development work. A fully operating computerized information system provides important data to decision makers for program budgeting (PPBS) and for cost-effectiveness evaluation of various old and experimental programs. Hence this project could relate to many others described herein.

6.8 Professional expertise required. Administrators, educators, experts in computer science and operations, systems planners, computer programmers, experts in various aspects of management information systems.

6.9 Estimated costs. The total effort of project staff and consultants required would be 15 man years. The costs are:

| | | |
|---|---|---|
| 1. Phase I, 2 years. | 96 man-months | $192,000 |
| 2. Phase II, 2 years. | 84 man-months | 168,000 |
| TOTAL | 180 man-months | $360,000 |

6.10 Appropriate countries for project. Korea, Colombia, and Mexico all have large and complex national educational systems in the process of modernization. All have large computers and computer personnel with experience, and so would be appropriate countries for this project.

## References

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2. Bell, C. Can mathematical models contribute to efficiency in higher education? In A. M. Mood, C. Bell, L. Bogard, H. Brownlee, & J. McCloskey. Papers on efficiency in the management of higher education. Berkeley, Calif.: Carnegie Commission on Higher Education, 1972, 43-44.

3. Ibid., 45-47.

4. Ibid., 51-52.

5. Ibid., 53.

## 7. Proposed Project 7, Priority A

## MAKING INEXPENSIVE TV RECEIVERS

This is a study of how to make inexpensive black and white TV receivers available in less developed countries so as to cut costs of formal and nonformal educational TV.

7.1 Objectives. The effectiveness of television for mass instruction has been demonstrated. At present, however, most of the estimated two billion potential buyers of TV receivers throughout the world cannot afford to obtain sets.

Development and marketing of black and white television receivers to sell at low cost would make possible mass instruction by TV in addition to recreational, political, and other uses of TV. If a sufficient market could be proved to exist, manufacturers or governments would probably undertake the necessary research to provide such low-cost sets.

The dual objectives of this study are, therefore: (a) to collect and analyze data concerning the number of prospective buyers of black and white television receivers during each year of the 10-year period 1973-1983 at several different costs in selected less developed countries; and (b) to determine the costs to manufacturers of the research and development necessary to produce black and white sets at a number of different prices and to secure information from manufacturers of the level of demand needed to induce them to enter the market at each of the different prices.

7.2 Levels and subsystem or subsystems involved in this study. Organization and society levels. Channel and net subsystem, receiver component.

7.3 Existing relevant research. Research on lower-cost black-and-white television receivers has been abandoned in favor of research on the problems of improving reception of color television. Color adds something to the value of TV as an instructional medium. Just how much is unknown. Color TV is, of course, significantly more costly than black and white. It cannot be used to meet the needs of developing countries in the foreseeable future.

Previous studies have shown that technology exists now that would make possible production of receivers at costs as low as $25 per set. The minimum cost in less developed countries is now $80. Receiver costs account for between 40 and 60 percent of the total costs of a nation's TV system, so the potential savings which could accrue from putting $25 sets into production are tremendous.

7.4 The research design. It is proposed to approach objective (a) by analysis of the market for TV in Asian, Latin American, and African countries. Objective (b) is to be furthered by contacting manufacturers to determine the market size at which they would be willing to invest in the necessary research on black and white TV.

(a) The initial phase of the market study would be a review of existing statistics concerning population, income, availability of power, number of existing TV sets, and present use of surplus income, to determine how much of the surplus is being spent on recently introduced products like cars, scooters, movies, and radios. Three to five of the less developed countries in Asia and similar numbers in Latin America and Africa would be studied. The sample would be selected to include countries of different sizes, stages of development, and developmental potential. Larger nations such as India, Zaire, and Brazil, which are now making or contemplating major investments in television, would be of particular interest.

A market survey procedure would then be pretested by questioning small samples of potential buyers in different income groups in at least 3 less developed countries. After indicated revisions the survey would be administered to large samples in all the selected countries.

(b) Japanese, American, and European TV manufacturers would be interviewed to secure their opinions as to the market potential and their estimates of the amount of research and development money they would be willing to invest for different projected demands. These would not, of course, be firm commitments but they would permit an estimate that could be used in conjunction with consumers' cost-demand curves.

The final part of the project will be data analysis. This would be expected to yield:

(a) A cost-demand curve for each selected country.

(b) An aggregated cost-demand curve for the total market in the less developed countries under consideration.

(c) Estimates of research and development costs for reducing the prices of TV receivers to a number of selected prices.

And (d) information as to the potential availability of research and development funds at different projected costs and amounts of demand.

7.5 Staffing and scheduling. It is proposed that a management consulting firm experienced in market analysis be engaged to carry out this study, using market research teams native to each country to do the surveys and interviews.

The schedule for the project should cover approximately one year. The sample selection and design phase should take about four months; the field work another four months; and the data analysis and report writing an additional four months.

7.6. Steps required to translate findings into operational use. If the study should reveal a high potential demand for sets at a price at which it would be practical to produce them, such findings by themselves might induce manufacturers to undertake the necessary research and development to make low-cost sets. If no interest can be elicited even with high demand, funds might become available from international agencies in the form of inducement loans or grants to industry for underwriting the research and manufacturing costs for a venture by one or more of the less developed countries, such as India.

7.7 Coordination with other research and development work. There appears to be no work currently underway to cut costs of black and white TV sets. This research should be coordinated with any project to produce black and white TV sets in a less developed country.

Currently in India educational TV including the planned TV satellite system is expected to rely on receivers manufactured in India. However, the cost of these sets in India will be about $250, compared with the $80 to $100 cost of imported sets. The Indians feel they must operate in this manner in order to enhance the autonomy of their television system, lessen their expenditure of foreign exchange, and create a new Indian industry. A study needs to be carried out to determine how human and technological capability present in some developing countries can be organized to create and maintain a self-sustaining industry that manufactures low-cost television sets in adequate quantities to make national educational TV possible. What we know about how to do this comes from experience in industrialized countries whose purchasers will pay a price higher than can be paid by citizens of less developed countries. A new organization and new methods particularly suited to less developed countries are needed.

This project should also be coordinated with programs to manufacture TV cassettes, cassette players, discs, and disc players because with cheaper black and white TV sets there could be increased use of such auxiliary components. The availability of cheap TV sets can also significantly alter costs of entire systems of microwave- and satellite-transmitted educational TV.

7.8 Professional expertise required. The study would require television engineers, economists, statisticians, survey designers, market research experts, and local interviewers.

7.9 Estimated costs. The estimated amount of labor for the necessary specialists is 5 man-years. To that must be added the local costs of the survey teams that are to be engaged in each country. Figuring on four people working for 3 weeks in each country, the total labor requirement for each country will be 3 man-months. If ten countries are surveyed, the total additional labor, beyond that supplied by the prime contractor, will be about 2-1/2 man-years.

| | | Costs |
|---|---|---|
| 1. Initial data collection and sample selection | 2 man-months | $ 4,000 |
| 2. Survey design | | |
| (a) Demand curve | 9 man-months | 18,000 |

| | | Costs |
|---|---|---|
| (b) Manufacturers' opinions | 6 man-months | $ 12,000 |
| 3. Test and revision of instruments | 6 man-months | 12,000 |
| 4. Field work | | |
| (a) Arranging survey and subcontracting | 9 man-months | 18,000 |
| (b) Survey | 44 man-months | 50,000 |
| 5. Data analysis | 9 man-months | 18,000 |
| 6. Report writing | 5 man-months | 10,000 |
| TOTAL | 90 man-months | $142,000 |

This gives a total labor requirement for the project of 7 1/2 man-years for a survey that includes market studies in ten countries. A different sample size would obviously have different labor requirements.

7.10 Appropriate countries for project. As stated above, three to five Asian and similar numbers of Latin American and African countries will be selected for market analyses. Three especially good countries for this research are India, Zaire, and Brazil, because all are now making plans for extensive use of educational television. Both India and Brazil have multiple companies making black and white TV, and in addition color TV is now in very limited use in Rio. Black and white sets are not being made in anything like adequate quantities in either India or Brazil to meet the needs of a nation-wide educational TV program. If Zaire were to manufacture its own sets, it would have to begin at the beginning to plan the manufacturing program and carry it through implementation with the assistance of foreign consultants and production managers. Malaysia is another country where such a project would be appropriate, since it has no TV manufacturing capability but has in the last two years received a gift from West Germany of 10,000 black and white TV sets to use in establishing an educational TV program.

## 8. Proposed Project 8, Priority A

### IMPROVING ACCEPTANCE OF INSTRUCTIONAL TV

This is a study of how to facilitate acceptance of an educational innovation, specifically instructional TV, by administrators, teachers, paraprofessionals, students, parents, and other key members of the community in less developed countries.

8.1 Objectives. Introduction of instructional TV as an educational innovation has usually been complicated by resistance and opposition on the part of key members of the communities concerned. Educators have felt that their jobs were threatened or that their relationships with their students would deteriorate. Parents, students, and other interested people have feared lowered quality of instruction. In some places these negative attitudes have been dealt with in an authoritarian way. Their existence, however, hampers both introduction and operation of instructional TV. The objectives of this research, therefore, are to survey countries that have recently begun to use instructional TV in order to anticipate the problems that can be expected to arise in countries planning to introduce such programs, and to find ways to increase understanding and reduce opposition to them.

8.2 Levels and subsystem or subsystems involved in this study. Levels are group (groups of key people) and organization (schools, cities, or towns). Subsystems are the internal transducer, the associator, and the decider.

8.3 Existing relevant research. For the initial survey (see below) the literature on methods of attitude research is relevant. Three volumes issued by the UNESCO International Institute for Educational Planning summarize the experience of 23 educational projects which use media.[1] Background material on innovation, which can be found in Roger's Diffusion of Innovations, sheds light on the characteristics of innovations, the nature of innovations, and the setting in which they can be expected to be accepted.[2] The nature of the information network in which innovations are successfully introduced is elucidated by Allen, Piepmeier, and Cooney, Technology Transfer to Developing Countries: The International Technological Gatekeeper. Their term "gatekeeper" refers to deciders in the channel and net subsystem and can influence whether or not innovations spread throughout an organization or society. They report that a study of the Irish research and development organization indicated that "technological gatekeepers must be well integrated into two information networks, an external network of information sources and an internal network of users to whom the information can be delivered."[3]

Studies of organizations in less developed countries have been made by Riggs, reported in his book on Administration in Developing Countries: The Theory of Prismatic Society, and by the Institutional Research Group at Michigan State University and the Universities of Pittsburgh, Syracuse, and Indiana.[4] This makes the points that effective institutions in less developed countries must have capable leaders, an underlying doctrine, a program, a clearcut internal structure, linkages with other institutions, and adequate resources for continued existence.

Further relevant material can be found in the work of David McClelland, David Apter, Philip Foster and Rene Cligny, James Coleman, and Aristide Zolberg. These all provide information on the factors that influence individual leaders to favor the adoption of innovative technologies.

Relevant to the objective of decreasing opposition to instructional TV are the literatures on attitude change and also the growing body of experience in the field of planning and managing short, intensive training sessions on decision making and systems management developed by various industrial organizations for management training.

The many recent studies of use of instructional media in teaching instructors also have some relevance. Among these are programs designed to aid American Indian instructors in Navajo language and literature.

8.4 The research design. This study would consist of four separate but related phases:

(1) Phase I, six months. A series of confidential interviews would be held with people in less developed countries who have experienced the introduction of instructional TV into their communities. The interview schedule would be designed to disclose the sorts of resistances which were encountered, the groups, organizations, or individuals who were most influential in opposing or facilitating implementation of the programs, and the methods that were used to overcome resistance and gain cooperation in the involved communities. Less developed countries in which educational TV has been established include: Colombia, El Salvador, Brazil (Rio Grande do Norte), the Ivory Coast, Niger, Malaysia, Singapore, and India. Interviews would be conducted in these countries.

A written report would be prepared, presenting the results of these interviews. It would carefully protect the identity of interviewers if they wished and also omit any references which might be personally damaging to individuals involved in any way in the decisions about instructional TV.

The final activity of Phase I would be a meeting held in the United States and chaired by the overall project director. This would include representatives of the countries in which the interviews had been held, educational decision makers from the countries to be included in Phase II (see below), experts in instructional TV, and consultants on attitudiual change and innovation, such as Everett M. Rogers and Carl Rogers. This would be a planning session for Phase II.

(2) Phase II, six months. An experiment would be conducted in Brazil, Venezuela, and Nigeria, all of which are in the early stages of planning and introducing instructional TV. In each of these countries, two large cities would be selected for study. These would be cities that were to have instructional TV introduced within the next few months. In the first city, which would act as a control, no particular preparation for introduction of the innovation would be made. This has been the usual procedure in countries which have implemented their instructional TV programs. That is, a decision has been reached at the higher echelons of the educational system and communities have been expected to comply with it. Implementation has typically been resisted. In Brazil, which has experienced resistance to introduction of instructional TV into the state of Rio Grande do Norte and elsewhere, a representative community in that region would be chosen as a special control in addition to another community just beginning to use instructional TV.

The second city in each country would be assigned to the experimental condition. In Brazil, this would be in a state other than Rio Grande do Norte--say, Rio Grande do Sul which now has plans to undertake a statewide TV program. In these communities, educational and governmental leaders would be interviewed to determine which members of the community could be regarded as leaders of opinion and "gatekeepers" for innovation. After these people had been identified, a group of 20 or 30 who were willing to participate in training sessions and to work as change agents, for remuneration, would be formed. These could be expected to include educational administrators, school principals, community business leaders, teachers and student leaders from a number of different schools.

In each country, a week of meetings would be held in which the technical and educational aspects of the medium would be explained; key people from other less developed countries in which instructional TV had been established would share their experience; free expression of positive and negative attitudes would be encouraged; and modern techniques of attitude change such as role playing, viewing of filmed role models depicting the teaching process using the medium, and some of the methods of encounter groups would be used. These sessions would be conducted by a team of skilled consultants. The change agents would then begin to work on a part-time basis in their communities, holding meetings and interviews and consulting with influential people. Also community attitudes on matters relevant to instructional TV and education would be tested by interviews and surveys to get a baseline measure. The survey sample would include members of involved segments of the population such as parents, students, teachers, educational administrators, and leading citizens.

(3) Phase III, one year. Throughout this phase, the change agents would continue to work on a part-time basis. During this period the instructional TV program would be introduced in each community and data collectors would again test attitudes in the communities by means of interviews and surveys.

(4) Phase IV, six months. This would be a period of data analysis and report writing. From this would result a book that would be designed to help developing nations with problems of introducing this and other technological innovations.

8.5 Staffing and scheduling. Staff requirements would differ in the four phases of the research. Phase I would need an overall project director, an associate project director, and a secretary. These personnel might be located in the United States. The interviews and written report on them would be the responsibility of the director and associate director. They would also arrange and conduct the meeting in which their findings were discussed.

Phase II would require the services of an overall project director, an associate director, project directors from each of the countries participating in the study, and six consultants. A research and statistical analyst, the selected change agents, and two secretaries would complete the staff. The schedule would be as follows: three months to select the change agents and hold three weeks of training sessions, one week in each country. In the last three months the change agents would work and surveys would be conducted.

Phase III would be carried out by the overall project director and associate director, three national project directors, three data collectors and analysts, the part-time change agents, and four secretaries.

Phase IV to last 6 months, would require only the overall project director and associate director, three national project directors, and three data analysts and statisticians, and four secretaries.

The overall time for the entire study would be 2 1/2 years.

8.6 Steps required to translate findings into operational use. The findings in the final report would be reported in educational journals and meetings of educators in the countries involved, as well as international meetings. Discussions would be held as to implications of the study for other communities planning to begin instructional TV.

8.7 Coordination with other research and development work. This study would be useful to any agency interested in introducing innovations into less developed countries. It would be coordinated with other efforts at establishing instructional media--not only TV but all the others--in less developed countries which might be expected to face similar problems.

8.8 Professional expertise required. Experts in research planning and directing; survey and interview experts; data analysts and statisticians; and experts in attitude changing and introduction of innovations.

8.9 Estimated costs. The estimated amount of labor of the necessary specialists is 17 man-years. Most of them might come from less developed countries. To that must be added the labor of the change agents, data collectors, and secretaries, all of whom will be recruited locally. The costs would be:

| | | |
|---|---|---|
| Phase I | 24 man-months | $ 48,000 |
| Phase II | 60 man-months | 120,000 |
| Phase III | 180 man-months | 360,000 |
| Phase IV | 72 man-months | 144,000 |
| TOTAL | 336 man-months | $672,000 |

8.10 Appropriate countries for project. The countries listed above would be visited during Phase I to learn about their experiences, but it is recommended that the final study will be carried out in Venezuela, Brazil, and Nigeria.

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## 9. Proposed Project 9, Priority A

## MINICOMPUTERS VS. LARGE COMPUTERS

This is a comparison of the cost-effectiveness of local minicomputers vs. very large computers accessed over distance by a network, for computer-aided or computer-managed instruction (CAI and CMI). CAI differs from CMI in that in CAI, all instructional materials are on-line or available through the terminal, but in CMI the student may be referred by the terminal to books, pictures, or other instructional materials which are not on-line, after consulting which he returns to the terminal for testing on them or other interaction.

9.1 Objectives. Objectives of this project are to determine the feasibility of CAI or CMI for use in less developed countries and to compare the cost-effectiveness of the two types of CAI or CMI systems, (a) decentralized with local minicomputers and (b) centralized with very large regional computers connected to terminals by a network. A test of both systems in a less developed country would indicate what trade-offs between length of channels in the network and size effect their relative costs and effectiveness and would demonstrate the strengths and weaknesses of each system. a less developed country would indicate their relative costs and effectiveness and would demonstrate the strengths and weaknesses of each system.

CAI and CMI have generally been considered too costly as presently operated, for use in less developed countries. New technological developments are cutting the costs, however. Because it has certain advantages over other instructional media, therefore, it is important to secure accurate information about both its present costs and its effectiveness. These advantages, as compared to instruction in classes or by broadcast, are primarily those of individualized instruction (see page 194). The student learns at his own rate, studies at times convenient to him, and since "branching" is possible, can by-pass material which is already familiar. The student also receives immediate feedback on his successes and errors. In addition, the computer can keep detailed records of his learning performance, so that tests and final examinations are unnecessary. CAI or CMI are more costly than broadcast instruction and certainly more so than instruction by either teachers or paraprofessionals. Its use would probably be indicated in higher education, where quality in advanced and specialized instruction is of particular importance and where costs per student of traditional education are high, rather than in primary and secondary schools.

CAI or CMI could possibly become cost-effective in two ways. It appears now that either very large computers capable of time-sharing hundreds of terminals over telephone lines or cables, microwave links, or satellite, or inexpensive minicomputers might reduce the cost of instruction per student hour to the point that less developed countries could have the advantage of this form of instructional technology. CMI might be even cheaper than CAI if terminals were used less by each student and their use were supplemented by books and other instructional aids. A major problem with the use of large regional computers is that terrestrial electronic communication networks in many of the less developed countries have been notoriously unreliable.

9.2 Levels and subsystem or subsystems involved in this study. The levels are the organization and the society. The subsystems are the channel component of the channel and net subsystem and the associator subsystem.

9.3 Existing relevant research. Cost studies reported above (see Table 7, page 121) have indicated that in the past CAI and CMI have cost between $2 and $25 per student hour. But things are changing. Minicomputers with the power of two IBM 7094's are expected to be available soon at a cost at or below $2,000.[1] Several sorts of inexpensive minicomputers of various sorts are on the market. New breakthroughs in costs of large computers have also occurred. A large computer, like the IBM 370, model 165 or the Burroughs 6700, capable of serving 4000 remote terminals, can cost less than $1 million.

Experience with CAI or CMI in a number of places is also relevent. The Pilot Medical School of Ohio State University is teaching preclinical subjects by CMI. In general the students and faculty find it satisfactory.[2] Certain other universities have set up remote terminals to the Ohio State system. Also the Federal University of Rio de Janeiro is beginning to adapt the software of this system for both large and minicomputers, and is studying the feasibility of disseminating this sort of instruction to other Brazilian medical schools. The PLATO project at the University of Illinois is giving a wide range of college courses by CAI and other campuses are now beginning to use it. Numerous other programs employing CAI are now in development or under way.

There is also related basic research on the relative advantages of centralizing or decentralizing information processing systems, which is the fundamental question in this project. According to Kochen and Deutsch, a decision in such matters depends on factors like the length of the channels in the network, how much they are used, their channel capacities, the length of messages sent over them, the amount of their operating costs, and the comparative growths of each channel's use and of its channel capacity.[3]

9.4 The research design. The project would be carried out in a less developed country such as Brazil, Venezuela, or India, where very large computers are available and where minicomputers are available or can be imported.

(1) Phase I, one year. The project team would be recruited. The schools and universities in which the project would be carried out would be selected, and the procurement of the necessary hardware and software would be arranged. It may be possible to use software prepared elsewhere, or it may be necessary to write software especially for this project. The latter alternative is more likely, and the budget is based on that assumption.

(2) Phase II, one year. After assembling the hardware and software and pretesting them, full course programs would be provided by CAI or CMI to 12 secondary schools and 12 universities in the selected country. These courses would be presented by terminals connected either to a large computer accessed over appropriate data links or to minicomputers placed in each institution. Six schools and six universities would use a central large computer, and six of each would use minicomputers. Forty terminals would be installed in each institution, a number sufficient, on staggered daily schedules, to serve more than 200 students (i.e., more than five students per terminal). In the total project at least 10,000 students would receive CAI or CMI.

The programs would operate for one academic year.

Careful daily records of operations would be kept. Data would be recorded on the progress of the students and their attitudes to this form of instruction and comparison data will be collected for control groups of students taking the same courses by traditional means. Cost figures on all aspects of these activities would be collected.

(3) Phase III, one year. First the data collected would be analyzed to yield information relevant to a number of questions such as the following:

- Do either the large computers or the minicomputers have an excessive amount of down-time? (The down-time of a central computer would affect all institutions, but that of a minicomputer would affect only one.)
- What problems arise in correcting and updating programs in minicomputers? Is it harder to keep 12 minicomputers operating correctly than one central computer?
- What are comparative service costs to minicomputers and to the central computer?
- What problems arise in securing local service for minicomputers?
- What effects do increased line charges over long distances have upon the comparative costs of the two systems? At what distance does it become more cost-effective to provide minicomputers rather than pay line charges for access to the central computer?
- Does the amount of usage of the channels and terminals alter the cost-effectiveness of either the central computer or the minicomputers?
- Does the length of the average message transmitted between the terminals and the computer affect the cost-effectiveness of either configuration?
- How do the channel capacities of the various channels affect the cost-effectiveness of the two configurations? Does increasing use alter such effects?

- Are the costs of either or both programs so great that they are not feasible as standard educational activities in less developed countries?

- If they are feasible, what are the minimal and optimal numbers of students per year to justify them?

After the data were completely analyzed the final report would be written. Then it would be desirable actively to initiate plans to expand the use of CAI or CMI in less developed countries if either computer configuration turned out to be sufficiently cost-effective.

9.5 Staffing and scheduling. If fully qualified all personnel in this study could come from the host country, but qualifications should be carefully reviewed, especially for the director. Knowledge of research design, instructional technology, and computers are essential for him.

(1) Phase I, one year. The director, associate director, six computer programmers, two computer operators, one communications engineer, two data collectors and analysts, and two secretaries.

(2) Phase II, one year. The same staff, except only two computer programmers would be needed since most course programming and adaptation would have been completed by the end of Phase I.

(3) Phase III, one year. Director, associate director, communications engineer, and two secretaries.

9.6 Steps required to translate findings into operational use. Findings of such a study would be applicable to less developed countries with comparable computing facilities. They would assist deciders in choosing what sort of CAI or CMI system would be most cost-effective for their countries, if the current project shows that to be feasible. These modes of instruction are much less well known and understood than radio or TV, and without aggressive publicity of the results of the study by lectures, seminars, planning sessions, and publications in various less developed countries, the work may take a long time to have impact.

9.7 Coordination with other research and development work. Results of this project would contribute to the growing body of information about CAI and CMI. It would be worthwhile to compare their cost-effectiveness with that of TV and radio.

9.8 Professional expertise required. The project would require experts in instructional technology, in education, in computer programming and operating, a communications engineer, data collectors and analysts.

9.9 Estimated costs. It is assumed that all operating personnel involved in this study will come from and be paid by the host country. This project would require 27 man-years. The personnel requirements and estimated dollar costs are as follows:

| | | | |
|---|---|---|---|
| 1. Phase I, one year | 156 man-months | | $312,000 |
| 2. Phase II, one year | 108 man-months | | 216,000 |
| Central computer time rental | | $100,000 | |
| Data links | | 100,000 | |
| 12 Minicomputers, purchased at $2,000 each (year rental would be more than $6,000 at $500 + each) | | 24,000 | |
| 960 terminals at $100 each | | 96,000 | |
| Subtotal | | | 320,000 |
| 3. Phase III, one year | 60 man-months | | 120,000 |
| TOTAL | 324 man-months | | $968,000 |

9.10 Appropriate countries for project. Brazil, Argentina, and India, because they might well be able to afford and operate the computers and communication links necessary for this experiment. Foreign aid might be required to help pay for the hardware.

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## 10. Proposed Project 10, Priority A

## INTERNATIONAL SHARING OF COMPUTER MANAGED INSTRUCTION

This is a study of sharing of computer managed instructional resources between established and less developed countries.

10.1 Objectives. The objective of this study is to explore the feasibility of adapting CMI software produced to teach preclinical medical sciences in the United States for use in medical schools and training programs for dentists, nurses, veterinarians, and other allied health personnel in several less developed countries.

The present costs of both hardware and software for CMI or CAI are high enough to deter their use in many less developed countries even though they might be effective ways to provide high quality education in some fields. The cost-effectiveness of instructional technology in these countries could be substantially improved if development expenses of computer facilities, educational satellites to transmit CMI or CAI signals, and programmed instructional materials were shared internationally.

An example of the use of CMI materials developed in one country by a university in another country, is the current project to translate into Portuguese and adapt the software of the Ohio State Pilot Medical Program so that it can be used to teach Brazilian medical students at the Federal University of Rio de Janeiro and perhaps at other Portuguese-speaking schools. This CMI program contains the usual content of the two years of medical school, which are preclinical instruction in basic medical science.

Individual students can interact with it in a conversational mode at a computer terminal which is augmented by a slide projector showing coordinated visual materials. Also additional printed materials are provided.

The project we propose here would have the goal of extending the use of the Ohio State Pilot Medical Program to other countries studying ways in which it should be adapted for most effective use. Specifically we suggest translating it into Spanish and experimenting with its use in health training programs in less developed countries that use Spanish or English. It is further proposed that its usefulness be tested for teaching basic medical sciences to dentists, nurses, veterinarians, and other allied health professionals. Paraprofessionals can be expected to provide most of the medical services in many less developed countries, particularly in the rural areas.

10.2 Levels and subsystem or subsystems involved in this study. The levels are the organization, the society, and the supranational system. The subsystems are the three components of the channel and net subsytem; the associator subsystem; and the memory subsystem.

10.3 Existing relevant research. Some experiments in cooperation among different educational institutions of the United States in the use of CAI and CMI have been successful. These include the use of remote terminals connected by telephone lines to the Stanford University computer for teaching linguistic and mathematical skills to school children in the South, and the cooperation between the University of Illinois and the University of Indiana in Project PLATO, which teaches college courses by

CAI (see page 373). Also the Ohio State Pilot Medical Program is being used by the medical schools of the Universities of Virginia and Wisconsin and will probably be used elsewhere in the United States. An international example of the sharing of another kind of instructional materials, is the cooperation by ten African countries in developing the ENTEBBE series of modern elementary school mathematics textbooks. Another one is the Latin American textbook exchange. The Open University curricular materials (see page 460) and "Sesame Street" (see page 281), have been adapted for use in more than one country. And, of course, the Ohio State Pilot Medical Program is being used in Brazil.

10.4 The research design. This project would be carried out in less developed countries in which a medical school or other health training program had access to a computer.

Phase I, two years. The Ohio State instructional materials would be translated into Spanish and the Spanish or English version would be adapted as needed for the local situation in three less developed countries, such as Panama, Argentina, and India. For instance, some of the technical terminology in regular use in the host country would differ from that in the Ohio State program. To illustrate: The disease known in the United States as "San Fernando Valley disease" is known as "Chagas disease" in Brazil. Also the incidence of this illness is different in North and South America, and this might require alterations of some statements in the program. Other sorts of alterations would be needed when content materials of the first year of medical school in the United States repeated courses included in premedical programs in another country, or when prerequisites for a certain course were taught in the host country.

If the prior training of nurses and other allied health personnel did not include necessary prerequisites, the required materials would have to be provided. Also the program might have to be simplified at some places for them.

Phase II, two years. The translated and/or modified program would then be tested in use in various medical and allied health training programs in three less developed countries, possibly Panama and Argentina, in which Spanish is spoken, and India, in which English is used in higher education. In each of these control groups of students would be instructed in the usual manner, by lecturers and textbooks, while matched experimental groups of students in various health specialties would receive the CMI instruction. Both control and experimental students would be given the same examinations, on a regular schedule before, during, and after each course. Data collected over two years would include careful records of each student's progress kept by the faculty of each cooperating training institution; grades for each student on the examination; and grades of students from prior years, to provide a base line.

The students taught by the CMI, in each of the health specialties, would be compared with others in their own school and with those in other countries, including the United States, on rate of progress through the program and on success as measured by tests. Faculty members and students would be interviewed to discover whether or not they liked the CMI instruction and what they perceived as special problems. Faculty members would also be asked how much additional help beyond the CMI the students had needed and in what specific aspects of the subject-matter. Also any changes made by the faculties in the CMI program would be noted. Careful records of all costs and savings would be kept.

These data would make it possible to discover how much adaptation this program required for use in the various specific less developed countries and what specific cultural factors facilitate or impede its acceptance and success in these places. Evidence on the general issue of the feasibility of using CMI or CAI internationally could be obtained.

Phase III, one year. Data analysis would be completed and a final report written. The results would be discussed with governmental officials, health educators, and health professionals in the host countries to see if the program should be extended there. They would also be discussed with comparable persons in other countries which give instruction in Spanish or English, to see if the CMI programs could be used there also.

10.5 Staffing and scheduling. The project director should be a person experienced in the use of CMI or CAI. He would need an associate who would spend part of his time at Ohio State to maintain liaison there and facilitate the transfer of the original CMI materials (plus further updated materials) to the host countries' institutions, which he should visit on a regular basis. In each of the three cooperating less developed countries there should be translators and programmers. (Altogether three translators in the two Spanish-speaking countries and two programmers in each of the three countries). The project would also need a total of five secretaries, two in the main office and one each in each of the host countries. All personnel in the host countries could be citizens of these countries, but at least one would need advanced training in computer science. It is assumed that all operating and instructional costs would be borne by the host countries. The project would, however, pay for the hardware rental for the first five years. The schedule, as indicated above, would be:

1. Phase I, two years. Assembling staffs, preparing CMI materials for local use, and arranging for computer services.

2. Phase II, two years. Conducting the CMI and collecting data on the control and experimental students.

3. Phase III, one year. Continuing the instruction, analyzing data, writing final report, and planning for future CMI use, if any, including amount of future fees to be paid for use of software.

10.6 Steps required to translate findings into operational use. As indicated above, the experiment and its findings would be discussed with appropriate interested persons. Also many people would visit the project and see it in operation, which would undoubtedly affect their attitudes toward such instruction. Most visitors to the Ohio State program have had very favorable reactions to it.

10.7 Coordination with research and development work. Of course Project 9 above, comparing large central computers versus minicomputers for CAI and CMI, is closely related. Each host country would have to decide which computer configuration were best in each institution which cooperated with Project 10. The Federal University of Rio de Janeiro is studying this question in relation to the Portuguese version. Other projects on CAI and CMI also are obviously also relevant.

10.8 Professional expertise required. Health educators, CMI experts, computer programmers, translators.

10.9 Estimated costs. The total labor required for this project over five years in three countries would be 40 man-years. In addition, each country would need approximately $50,000 a year for five years to rent computer time and terminals or to buy such hardware. The costs:

| | Manpower Needs | Manpower Costs | Equipment Costs | Total Costs |
|---|---|---|---|---|
| 1. Phase I, two years | 192 man-months | $384,000 | $150,000 | $ 534,000 |
| 2. Phase II, two years | 192 man-months | 384,000 | 150,000 | 534,000 |
| 3. Phase III, one year | 96 man-months | 192,000 | 150,000 | 342,000 |
| TOTAL | 480 man-months | $860,000 | $450,000 | $1,410,000 |

10.10 Appropriate countries for project. For the reasons discussed in Sections 10.1 and 10.4 above, Panama, Argentina, and India.

## 11. Proposed Project 11, Priority A

## CENTRALIZED VS. DECENTRALIZED EDUCATIONAL SYSTEMS

This is a comparison of the cost-effectiveness of centralized vs. decentralized educational systems, from the extreme of possible centralization, an international system, to national state, and local systems.

11.1 Objectives. The prime objective of this study is to examine national educational systems with different degrees of centralization of their decider subsystems, in order to determine the circumstances under which centralization or decentralization might be more cost-effective in less developed countries.

At present, no international educational system is available for study. Plans for international universities are being formulated by the United Nations and by several other agencies. A growing number of instances of international cooperation in education can be found however. One is the relationship between the Pilot Medical School of Ohio State University and the Medical School of the Federal University of Rio de Janeiro (see Proposed Project 9, page 371). Another is the link between Stanford University and the Space Agency of Brazil by which seminars are conducted over TV live by satellite between Stanford and the Space Agency. The educational TV program Sesame Street is also used in several countries besides the United States where it originated. It has been reenacted in Spanish for use in Mexico and in Portuguese for use in Brazil. Also four colleges in the United States and one in Bermuda are using instructional materials produced by the Open University of the United Kingdom. And there are other examples of sharing of instructional materials among educational systems in different countries.

Commercial interests are also interested in dissemination of instructional materials throughout the world. These include such things as audio cassettes for instruction language put out by Berlitz and others.

Except for the various international university proposals which are now only in the blue-print stage, these activities are not conceived of as concrete systems. They lack a central decider which can integrate the various components to constitute a complete educational system. It is important to consider factors related to their cost-effectiveness, however, because some sort of organized international sharing of educational resources will almost certainly come into existence in the near future, taking advantage of the fact that channels and nets can and do cross international borders.

*11.2 Levels and subsystem or subsystems involved in this study*. Levels are the organization, the society, and the supranational system. Subsystems are the transmitter and the channel components of the channel and net subsystem, as well as the decider subsystem.

*11.3 Existing relevant research*. Research on centralization and decentralization of organizations is relevant to school systems, which are one type of organization. Meyer studied 254 city, country, and state departments of finance and found that decision-making authority became more highly centralized as the number of subordinate organizations or groups in an organization grew.[1] As the number of echelons in the decider increased, however, decentralization went up and rules promulgated by the top echelons to guide organization-wide decisions proliferated. Problems of coordination among components of organizations are discussed by March and Simon.[2] They make the distinction between coordination by plan and coordination by feedback. This is relevant to coordination among the many schools spread through the territory of a country. Analyses by Miller of centralization and decentralization in organizations are relevant to educational systems as well as other organizations.[3] Also Kochen and Deutsch have developed mathematical models of centralization-decentralization the results of which have suggested a number of the hypotheses listed in the next section.[4]

11.4 The research design. Because no international educational system yet exists the actual research effort must of necessity be limited to the group, organization, and society levels. Six less developed countries whose educational systems are organized with different degrees of centralization of their decision making processes would be participants in the project. Highly decentralized systems such as those of Afghanistan and Nepal would be the least centralized systems. India and Mexico, in both of which state rather than national control of education is dominant, would be suitable for the intermediate condition. Ethiopia and Costa Rica are good examples of countries with highly centralized systems.

The study would consist of interviews with administrators, teachers, and students in each of these six countries. An interview schedule would be followed by the interviewer in order to discover details of the organization of their educational systems. An attempt would be made to answer questions like: Where in the system are important decisions concerning curriculum, teacher qualifications, long-range planning, building programs, innovations, and spending made? What disparities exist among schools or regions in program content, amount of money spent per student per year, or number of years of education provided? Who selects and hires teachers? Are teachers equally competent throughout the system? Who gets promoted? How rapidly do new ideas, programs, or methods spread throughout the system? What are the lengths of channels that must be used to get a suggestion or complaint to someone able to act on it, that is, the number of offices through which it would have to be routed? What is the procedure for getting services like a TV receiver repaired or building repairs done and the approximate time such services would take? What is the length of distributor channels through which supplies, replacement parts, or technicians must pass to reach installations? What is the procedure for removing an incompetent teacher or administrator, and who makes a final decision of this sort? What are the comparative costs of operating the various systems?

The information obtained would be used to provide confirming or disconfirming evidence for a number of hypotheses concerning the effects of centralization and decentralization. These hypotheses are stated positively but it is understood that they are proposed not as facts but as statements for which evidence pro and con would be collected and weighed.

Some possible hypotheses, together with some measures which could serve to confirm or disconfirm them, are:

1. The more numerous the students and schools in a school system, in general the more echelons there are in their administrative structures.[5] Not only the present number of schools and students, and number of echelons, would be determined, but where possible, historical data would be obtained about the growth of the system and the expansion of its decider subsystem.

2. In general, the more money per capita a country devotes to education, the more cost-effective centralization is.[6] This might be true where, for example, enough funds are available to purchase a statewide instructional TV system to serve 500 schools. Such instruction might well be more cost-effective than traditional education decentralized to each school. Until the funds were available, however, the decentralized approach would have been mandatory. The data to evaluate this hypothesis include indices of per capita income, educational costs, and educational effectiveness as measured in ways like those discussed in Project 1 (see pages 267 to 307).

3. The more centralized a system is, the less variation there is in policies and administrative practices and the fewer inequities are found in the quality of education, in buildings, in equipment, and in the pay and work loads of teachers.[7] Data relevant to this hypothesis would be elicited in a straight forward manner from interview materials.

4. As decentralization increases, administrators in different parts of the country make more and more of their decisions without the benefit of relevant information existing elsewhere in the system. Consequently the decisions are often less satisfactory, and always less coordinated than they would be in a centralized system.[8]

Measures of the effectiveness of decisions and of agreement among decision makers would be developed to test this hypothesis.

5. So long as all relevant information flows among all echelons or components of the decider, to keep them all informed of states of the system, the more decentralized the decider of a system is, the better will be the adjustments made by its echelons or components.[9]

Expressed satisfactions or dissatisfactions of school principals or local superintendents would give some measure of the adequacy of the adjustments made. Principals, local school superintendents, and other officials stated impressions of how good is their access to information they need to conduct their activities and of how accurate is their view of the total system in which they operate, would be evidence of the adequacy of the information flow.

6. The more decentralized a system is, the more quickly and efficiently will local problems be solved.[10] Information on the length of distributor and channel components and the number of echelons that must be consulted before a final decision is made would relate to this hypothesis. Estimates of the amount of time it takes to get appropriate action would also be relevant. If, whenever a blackboard is broken, it is necessary to send a message to a remote capital city to get permission to obtain a replacement, a disadvantage of centralization is painfully apparent.

7. The more isolated a component is, the more it must depend upon its own resources or those in its immediate neighborhood for its needs.[11]

The round trip from Menaus to the most remote parts of the State of Amazonas, in Brazil, takes 24 days. Communications in the area are very poor. In such a situation no day-to-day centralized control can be exerted over details of local operations. Local administrators must be given some autonomy. Decentralization is forced upon such a system. Here a system would have primarily to use coordination by planning rather than coordination by feedback. That is, instead of expecting problems to be brought for immediate solution to central administrators, detailed contingency plans and standard operating procedures would be developed to meet every imaginable circumstance. Interviews would give rough measures of how isolated a component is as well as how much it relies on local resources.

8. (Related to Hypothesis 7.) The greater the distance over which supplies or services must travel, the more cost-effective will decentralization be.[12]

Measures to use in evaluating this hypothesis include the costs of transport or travel over the distance supplies and services must travel and indices of educational cost-effectiveness like those mentioned under Hypothesis 2.

9. As the decider becomes increasingly unresponsible so that a request must be made repeatedly before it gains attention, decentralization is more and more cost-effective.[13]

A decider of this sort is admittedly pathological, but in entrenched educational bureaucracies such pathology is common. Interview material would almost certainly disclose a situation of this sort where it exists and provide a rough measure of decider responsiveness. This could be compared with indices of educational cost-effectiveness like those mentioned under Hypothesis 2.

10. When a system is growing so rapidly that its administrative structure is inadequate to handle all the problems and requests that arise within it, decentralization of decision making is increasingly cost-effective.[14]

The rate of addition of new schools or services like nonformal educational programs, together with the satisfaction of administrators with the response to their reasonable requests or their expressed frustration could be compared with indices of educational cost-effectiveness like those mentioned under Hypothesis 2.

11. The less homogeneous is the culture of a country, the more cost-effective is decentralization. Where political units have different cultures and languages, as they do in India, a central decider has difficulty in controlling the whole system. A measure of cultural homogeneity would need to be constructed and compared with indices of educational cost-effectiveness like those mentioned under Hypothesis 2.

11.5 Staffing and scheduling. The project would require a national director in each of the countries involved in the research. These would be citizens of the countries concerned. One of these could act as overall project director. Each would have an associate director, and two interviewers who would also be data analysts. Two secretaries would be needed in each country.

In addition, consultants from the United States would advise as necessary in the specialty fields of research design, operations research, organization theory, sociology, test development, education, and interview techniques.

The project would take two years and include the following three phases: Phase I, six months, devoted to planning. Phase II, one year, for collecting data. And Phase III, six months, for analyzing the findings and writing the final report.

11.6 Steps required to translate findings into operational use. The findings would be applicable to planning by educational administrators and governmental policy makers in less developed countries. They could be made known through educational journals and international conferences of educators and policy makers.

11.7 Coordination with other research and development work. This project deals with one major determinant of cost-effectiveness of educational systems in less developed countries, and naturally should be analyzed for its relations to other cost-effectiveness studies like several of our other proposed projects.

11.8 Professional expertise required. Experts in research design, operations research, organization theory, sociology, test development, education, interview techniques, and data processing would be required.

11.9 Estimated costs. A total of 72 man-years of effort. The costs:

| | | |
|---|---|---|
| 1. Phase I, six months | 36 man-months x six countries = 216 man-months | $ 432,000 |
| 2. Phase II, one year | 72 man-months x six countries = 432 man-months | 864,000 |
| 3. Phase III, six months | 36 man-months x six countries = 216 man-months | 432,000 |
| TOTAL | 864 man-months | $1,728,000 |

11.10 Appropriate countries for project. Decentralized educational systems--Afghanistan and Nepal; moderately centralized educational systems--India and Mexico; highly centralized educational systems--Ethiopia and Costa Rica.

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   Also M. Kochen & K. W. Deutsch. Decentralization by function and location. Communication No. 267. Ann Arbor, Mich.: Mental Health Research Institute, University of Michigan, 1970.
5. Cf. Miller, J. G. Living systems: the organization. Op. cit., 2.
6. Cf. Kochen, M. & Deutsch, K. W. Decentralization by function and location. Op. cit., 23.
7. Cf. Miller, J. G. Living systems: the organization. Op. cit., 5.
8. Cf. Ibid.
9. Cf. Ibid.
10. Cf. Ibid.
11. Cf. Ibid.
12. Kochen, M. & Deutsch, K. W. Decentralization: a mathematical model. Op. cit., 1-6.
13. Cf. Ibid.
14. Cf. Ibid.

## 12. Proposed Project 12, Priority A

## CULTURAL AND SOCIOLOGICAL VARIABLES IN EDUCATION

This is a study of cultural and social variables affecting formal and nonformal education in less developed nations: values, motivation, curricular content, and adaptation to new technologies.

12.1 Objectives. The objectives of this field study are to analyze the effects of the above-mentioned variables upon the attitudes of rural people in less developed countries toward the formal and nonformal educational programs that are offered to them and to their children, in order to find ways to make the course material more relevant, attractive, and useful to them.

Ordinarily, educational programs are planned by administrators who may not share the culture of the rural people, and in some cases do not use the same language. This is particularly true if a less developed country has recently been a colony of another society. In these places, the language of the schools and of the people may be different. Language differences can also be found in less developed countries in which more than one cultural tradition is represented--Spanish and Indian, for example.

A further problem with educational systems in many of these countries is that most of the graduates of the schools do not find jobs commensurate with their education. A report to The Development Assistance Committee of the Organization for Economic Co-operation and Development (OECD) estimates that in some countries jobs are available for no more than 10 to 15 percent of the potential work force.[1] It is important, therefore, that the education offered should make two of its goals: (a) to improve the quality of the lives of people in their rural settings and (b) to prepare them to understand and participate in the social change and expanded opportunities that will accompany their country's development.

12.2 Levels and subsystem or subsystems involved in this study. The levels are the group, the organization, and the society. The subsystems are the input transducer; the transmitter, channel, and receiver of the channel and net; the associator; the memory; and the decider.

12.3 Existing relevant research. The large sociological literature that describes the differences between the way of life of people in small rural communities and those in urban centers provides background for studies like this one. Redfield's work on "the little community" described life in an isolated South American region.[2] The literature of anthropology also applies, especially that dealing with the effects of contact between people of different cultural backgrounds; the adoption of innovations in societies; and the family and tribal organizations that preceded modern governmental forms in many developing countries and are still important, particularly in remote and rural areas.

Experiences of educational projects in introducing social change, including educational innovations, are also relevant.

The "Mandoul" project carried out in Chad is directly related to this proposed study.[3] In 1966, the government of Chad undertook reforms in primary education with the objective of giving a basic education to the greatest possible number of people and of providing the country with the middle and senior managerial staff necessary to its progress.

A problem in Chad had been that children educated in the schools were alienated from the uneducated people in their home villages or rural areas. Classes were conducted in French. Parents sent their children to school to prepare them for civil service jobs but the civil service could not use all the graduates and those who were not placed did not find other jobs and could not become integrated into their villages. There was, consequently, resentment against the schools, teachers, and graduates.

An experimental project carried out in one village had the dual aim of providing the villagers with detailed information about the school and stimulating their awareness of their responsibilities toward school children.[4]

This project used the following methods:

(a) A series of meetings was held in the village square in which villagers described their ideas about the school and expressed their resentment toward the teachers. The teachers, with the help of rural development authorities, explained the schools and pointed out their potential usefulness if the village were to develop and take advantage of changes and innovations occurring elsewhere. (b) The villagers were then asked to describe the objectives of their traditional educational system and to become partners with the teachers in deciding which parts of it should be continued and which supplanted by new ideas. The report said:[5] "...the villagers felt that the children should learn production and craft methods, and the socioeconomic and sociopolitical rules of the community and should attend the initiation rites." (c) The villagers, with the help of the teachers, considered the positive aspects of the school and what it might contribute to the village welfare. They defined the role of the villagers as having to accept responsibility for school attendance and to take an interest in curricular content. The children's perception of a dichotomy between the school and the traditional world was to be changed by arranging cooperation between villagers and the school. The villagers then assigned some adults to discuss problems of children with the teacher on a weekly basis. Others were delegated to sit in on classes and report to the village about what was being taught and what methods were being used. And certain older villagers were asked to go to the school and talk to the pupils about the traditional ways and knowledge of the people. Villagers also suggested that children cultivate a field of cotten under supervision of an adult chosen by the villagers. Proceeds from sale of this cotten were to be used to clothe the children and to provide additional school materials.

This program resulted in interesting more and more villagers in the project. Also it obtained the support of traditional and administrative chiefs. A change in the relationship between teachers and villagers was very marked. The people chosen by the villagers to visit schools or take other responsibilities were scrupulous in their performance. A mimeographed newsletter was started in which pupils and villagers explained what they were doing and how they felt about it. The report concludes:[6]

"IT would of course be wrong to suggest that in other Chad villages, let alone other countries, such a task should be attempted in exactly the same way. In projects of this kind it is the action itself which matters far more than the specific aspects which are bound to vary from one setting or one context to another. Every village has its own particular features; to repeat what has been done at Matekaga would mean forcing a population along a path which it may not wish to follow. What has to be done is to discover and work out practical methods of action with the help of the population concerned...."

12.4 The research design. It is proposed that two villages in each of three different less developed countries, perhaps Cambodia, Peru, and Botswana, be chosen for field studies and demonstrations. If more than one cultural background exists in the country, villages should be selected so that the multiple cultures are represented, if possible. Giving heed to the warning, quoted in the last section, not to repeat exactly what was done at Matekaga, the study team should approach the villages in a spirit of trying to learn as much as possible about the values, motivations, and attitudes toward social change and innovation held by the people. Since it is desirable to form a basis of generalization from which educators can learn, procedures should, however be as comparable in all the villages as is consistent with relevant and responsive community work. More emphasis should be given to nonformal education than was done in the Chad project.

Phases in the project should be:

Phase I, six months. Recruit three teams, one each for each participant country and plan the project procedures.

Phase II, 1 1/2 years. In each community selected for study carry out the following steps:

(a) Gain the cooperation of the local teachers, school administrators, and nonformal educators by explaining the goals of the project. This presupposes cooperation on the part of governmental authorities and the higher echelons of the educational system in the country.

(b) Identify and contact others in the community whose good will and cooperation are necessary to the project and explain the objectives to them in detail.

(c) Hold meetings for any members of the community who wish to participate. These would give them an opportunity to express opinions and feelings, make suggestions as to what sort of subject matter they would like to have dealt with in formal or nonformal instructional programs, state their reactions to the courses of study available to them, formulate goals for community change, and suggest how the unique aspects of their culture could be preserved and used to enrich the national life.

(d) In the course of these meetings, the special needs of each community would be determined and then, in the light of those needs, cooperative action to make education more meaningful could be undertaken. Particular emphasis would be placed on nonformal adult education, adapting as appropriate to the traditional backgrounds of the adults.

(e) Data would be collected by taping the proceeds of important meetings and interviews and having all members of the staff write daily protocols or diaries. Periodically opinion surveys would be conducted in the community, including one at the beginning and one at the end of the community action period, as well as one at the end of a follow-up period of six months.

Phase III, one year. Follow-up period, data analysis, and final report writing and dissemination.

12.5 Staffing and scheduling. In each country a national project director and associate project director would be responsible for the conduct of the study. One of the national directors would be the overall project director. In each country either the director or the associate director should be trained in comparative anthropology and have a basic understanding of the culture of the people of the communities to be studied. The other one should be an educator. In addition, four staff members skilled in group work and capable of acting as change agents would conduct meetings and interviews. In each country an administrative assistant and a secretary would be assigned to the project. All personnel could come from the local countries but some consultants from abroad would be needed.

The project would occupy approximately 3 years, although the exact duration of the study in each community would be variable, depending on the cooperation obtained and many other social and political considerations.

Phase I, six months. Organizing the staff teams and planning the research approach.

Phase II, 1 1/2 years. Community action and field study.

Phase III, one year. Follow-up data processing, and preparation and dissemination of the final report.

12.6 Steps required to translate findings into operational use. The report generated as a result of these field studies would be of use in planning formal and nonformal educational programs in a way that is more responsive to local cultural factors and community attitudes. The staff and change agents might consider role playing typical community conversations from their study or playing parts of their tape recordings, with permission of the villagers, at educator's conferences and conventions.

12.7 Coordination with other research and development work. This study could contribute very practical insights about the development of educational systems for less developed countries, insights into how best to integrate traditional values and folkways into the formal and nonformal educational system and how different cultures react to innovation and change.

12.8 Professional expertise required. Applied anthropology, group work, educational planning, and data analysis.

12.9 Estimated costs. The total necessary amount of human effort of the staff and consultants would be 27 man-years for each country, or 81 man-years total if the project we carried out in three countries, as suggested. We assume that the equivalent of 1 man-year of consultant time would be needed in each country in each Phase, but that the other personnel could be indigenous to each country. The costs for a study in three countries, then, would be:

| | | |
|---|---|---|
| 1. Phase I, six months | 180 man-months | $ 360,000 |
| 2. Phase II, 1 1/2 years | 468 man-months | 936,000 |
| 3. Phase III, one year | 324 man-months | 648,000 |
| TOTAL | 972 man-months | $1,944,000 |

12.10 Appropriate countries for project. Cambodia, Peru, and Botswana. These countries are all relatively unadvanced as compared even with others of the less developed countries. Also they have pervasive traditional cultures, each quite different--and incidentally, all different from the culture of Chad, which is quite unlike Botswana even though they are both in Africa.

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3. French Delegation. The "Mandoul" project--a rural education experiment in Chad. Restricted information paper of Development Assistance Committee, Organization for Economic Cooperation and Development DAC(72)47. September, 1972. (Unpublished mimeograph.)
4. Ibid., 8-20.
5. Ibid., 12.
6. Ibid., 19.

## 13. Proposed Project 13, Priority A

## TEACHERS VS. PARAPROFESSIONALS

This is a comparison of the cost-effectiveness of instruction by fully trained teachers vs. that by paraprofessionals, with and without the aid of instructional technology.

13.1 Objectives. The objective of this study is to derive cost-effectiveness ratios for several different systems of instruction in order to help educators in less developed countries select a suitable system for use in their schools.

Recent interest in teaching innovations has concentrated upon the use of instructional technology to supplement what a professionally trained teacher traditionally does ( see pages 154 to 156 ). It is generally conceded that this is an effective way to teach. It is particularly suitable for professional or scientific education, in which a high degree of excellence is required. It is costly, however, since the costs of hardware and software for instruction by mass media are almost always simply added to current operating costs such as the salaries of trained teachers. Consequently most of the world's less developed countries either could not afford such instruction or would find it necessary to limit it. In some of these countries the shortage of fully trained teachers is great. As a consequence paraprofessionals, some of whom have a background of only a few years of primary school, must carry most of the teaching load. They may be called teachers, but they are not journeymen. The proper term for them is "paraprofessionals." They cannot be content experts, but must rely on some medium to present the subject-matter. They can, however, possibly learn how to manage the learning situation.

It is important, therefore, to explore alternatives by which educators in less developed countries can improve the quality of instruction they offer and remain within budgetary limits. These alternatives include not only ways paraprofessionals can be made effective as instructors, but different combinations of teachers and paraprofessionals with instructional media. An innovation in teaching method is another alternative--the use of behavior modifications based on operant conditioning theory.

13.2 Levels and subsystem or subsystems involved in this study. The levels are group, organization, and society. The subsystems are the transmitter, channel, and receiver of the channel and net subsystem, and the associator.

13.3 Existing relevant research. Two relatively new developments in psychology are of particular interest. These are the refinements of Skinner's techniques of operant conditioning and their application to classroom teaching, which is known as behavior modification.[1]

Operant conditioning is a technique of selectively rewarding any behavior pattern that the experimenter chooses, such as pecking at a key by pigeons or pulling of a string by rats. Such rewards can turn the action into a habit. Using operant conditioning, it is possible to establish any behavior pattern an animal can carry out as a response to any signal it can perceive. For a reward of corn pigeons can be trained to peck at a button any number of times or in any pattern. Complicated behavioral patterns are shaped from simple ones by selectively rewarding the desired behavior and varying the reward schedule. Responses other than the selected one are neither rewarded nor punished. Man and any species of organism capable of learning apparently can be conditioned in this way.

Human behavior modification techniques applied to education reward whatever behavior the teacher wishes to establish, every time it occurs. This behavior may be the correct pronunciation of a word, accurate comprehension of a concept, or the competent performance of a motor task. Rewards may be praised, points toward earning a grade or a privilege, or even tangible things like candy or small coins. Some research results indicate that teaching by this method can be significantly more effective than traditional methods. The use of behavior modification requires special training and must replace the teachers personal and often idiosyncratic mode of teaching and unscheduled use of reward and punishment.[2]

Also relevant are all the studies which compare instructional technology with traditional methods. Some of these have been discussed above (see pages 310 and 312).

13.4 The research design. This project would compare the cost-effectiveness of eight different teaching methods. There would be three major variables: (a) The training of the teachers would be varied by using fully trained professional teachers in some classes and paraprofessionals in others. (b) Teaching methods would be varied by using traditional teaching methods in some classes and behavior modification teaching techniques in others. (c) Use of instructional aids would be varied by using them in some classes and not in others. Such aids might be texts and workbooks, printed programmed instruction, radio, TV, or almost any other particular medium listed in

Table 7 (see page 117). Obviously the cost and effectiveness of these different media differ, but it is not proposed to make differences among media variables of the present study. Rather, a medium available in the country in which the experiment is conducted would be selected. If results justify it, a similar design could be applied in other countries at a later time, using another medium or other media.

Experimental conditions in this project would be:

Fully trained teacher

Without instructional aids

1. Traditional teaching
2. Behavior modification

With instructional aids

3. Traditional teaching
4. Behavior modification

Faraprofessional

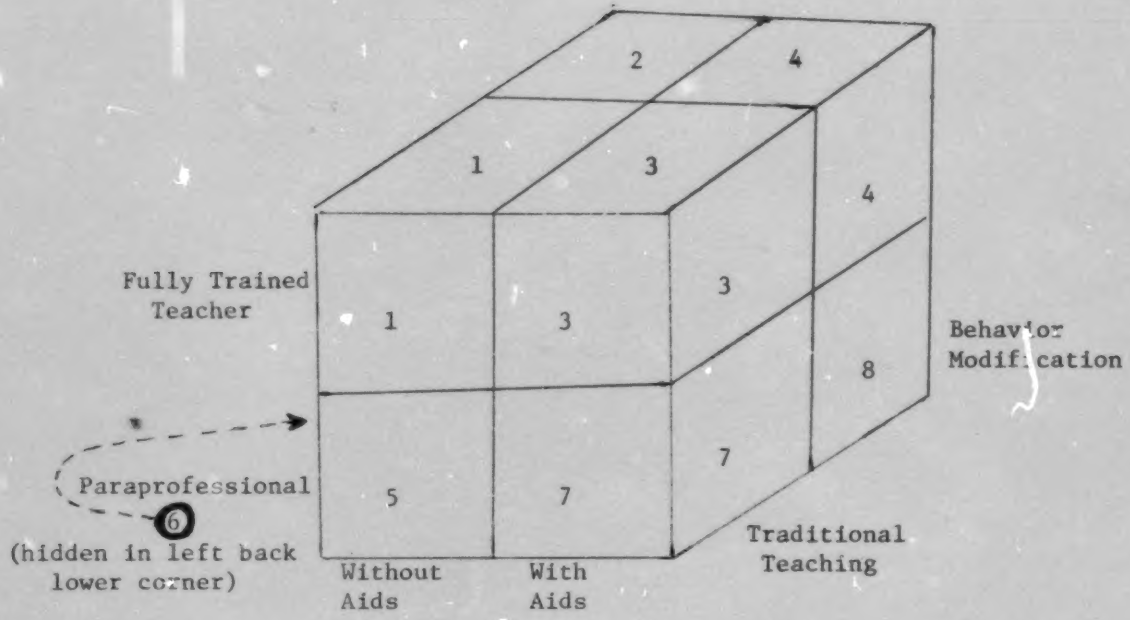
Without instructional aids

5. Traditional teaching
6. Behavior teaching

With instructional aids

7. Traditional teaching
8. Behavior modification

A three-dimensional chart of the 8 experimental conditions in the research design would take this form:


2
4
1
3
4
3
1
3
8
7
5
7
6
Fully Trained Teacher
Paraprofessional
(hidden in left back lower corner)
Behavior Modification
Traditional Teaching
Without Aids
With Aids

It is proposed that four classes be assigned to each condition, for a total of 32 classes. The four classes for any particular condition would each be in a different school. Any school could have two or more classes participating in the experiment just so long as there were no multiple classes in it assigned to any given condition.

The experiment would take place in three phases:

Phase I, six months. An initial planning period and training period for teachers and paraprofessionals who will use the behavior modification technique. The two types of teachers could be trained together since the techniques would presumably be new to both and both would have to change established teaching habits. The training would be conducted by an expert in the technique and he would use it in the training sessions. The intensive training course would last three months and include opportunities for practice teaching using behavior modification.

Phase II, approximately nine months. Instruction would be given in a selected course (e.g., 6th grade science) for one school year. The course should be one for which objective criteria of success and failure are available. The grade and average age of the students should be the same for all the classes. Costs considered in comparative cost-effectiveness calculations about the eight experimental conditions would include media costs, if they applied; teachers' and paraprofessionals' salaries; costs of traditional materials; and costs of a consultant to give the training in behavior modification and to supervise teachers and paraprofessionals using it. Effectiveness would be measured by pretesting of attainment in the subject-matter and regular monthly and final tests would be carried out. In addition, teachers and students would be given opportunities to express their satisfaction or dissatisfaction with the method by which they were taught.

Resistance to this project might be encountered by principals, teachers, parents, or political figures. In the United States, an attempt to use behavior modification experimentally in a suburban community did meet with popular resistance.

Phase III, six months. The final phase would be a period of data analysis and preparation of a written report. A major question would be whether paraprofessionals, likely to be less idiosyncratic than fully trained teachers, could therefore adhere more closely to a behavior modification teaching schedule. Another question would be whether the lower costs of paraprofessionals' salaries could make up for the extra costs of instructional aids.

13.5 Staffing and scheduling. The project would require the services of a project director and associate director from the country in which it was carried out, assisted by a secretary and an expert in research design and statistical methods. It would also require a consultant expert in behavior modification techniques.

A tentative schedule would be: Phase I, six months, a period of planning and training teachers and paraprofessionals in behavior modification methods.

Phase II, one school year, approximately nine months, the experimental period.

Phase III, six months, data analysis and preparation of final report. Total duration of project: about two years, nine months.

13.6 Steps required to translate findings into operational use. This would depend upon which method a country decided to use. If it were teachers, they would need training; if paraprofessionals, they would need it. If behavior modification were to be used, appropriate training must be given to all teachers or paraprofessionals who are to use it. As a group of teachers skilled in the method was developed, these could train others. If a combination of human beings and instructional technology is selected, the hardware and software, this must be provided.

13.7 Coordination with other research and development work. Results of this research would add to the store of information about comparative cost-effectiveness of different sorts of educational systems. It should also be coordinated with the extensive literature on operant conditioning experiments and technique of behavior modification.

13.8 Professional expertise required. Experts in instructional technology, statistical methods and data analysis, the conduct of educational experiments, and behavior modification are needed for this project.

13.9 Estimated costs. It is assumed that all teachers and paraprofessionals as well as all media operating personnel in the project will be paid by the host country. In addition the project would need a total of 10 man-years of personnel and the costs would be:

| | | |
|---|---|---|
| 1. Phase I, six months | 36 man-months | $ 72,000 |
| 2. Phase II, one year | 48 man-months | 96,000 |
| 3. Phase III, six months | 36 man-months | 72,000 |
| TOTAL | 120 man-months | $240,000 |

13.10 Appropriate countries for project. Appropriate countries for this project are Guatemala, Laos, and India where many of the so-called "teachers" are really paraprofessionals with only a few years of grade school training. In certain cases they have no further training at all.

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## 14. Proposed Project 14, Priority B.

## INTRODUCING USE OF INSTRUCTIONAL TECHNOLOGIES

This is a management study analyzing alternative strategies for introducing use of instructional technologies in educational systems.

14.1 Objectives. The chief objectives of this study are to identify a number of strategies for facilitating introduction of educational technologies into less developed countries and to determine what is the optimal "mix" of them for a particular country.

The major problem in beginning to use instructional technology in any educational system, whether in an established or in a less developed country, is the unavoidable initial expenditure which is required if the ultimate benefits are to be achieved. Since the costs of innovations of this sort are often greater than the costs of existing programs, the changes will usually not be undertaken unless the present programs are clearly less advantageous. Even then they may not be undertaken because the necessary funds cannot be obtained. Costs include those of discovering and developing the new course of action and ob obtaining whatever new artifacts such as buildings or equipment, or new employees are required. Other costs are the expense of training teachers, paraprofessionals, and other personnel in the new procedures, and the changeover costs from old to new procedures. Some of the resistance to change observed in educational systems arises from the greatly increased costs which initiation of innovations will incur. These costs may commit the educational system over long periods to the new methods of instruction and significantly reduce the funds available for capital investment and operation of the system.

Instructional technologies require specific sorts of hardware, as well as kinds of specialists who are ordinarily not parts of traditional educational systems. Programs must be developed. The society may have to expand or alter the equipment in its channel and net subsystem to provide more TV or radio channels and to extend them into towns and villages that have not previously had these media. Many more TV or radio receivers would be needed. Any textbooks in use throughout the system would have to be replaced with workbooks or other printed materials related to the new programs. Other technologies have other expensive requirements, such as slides or audio or video tapes, and machines to use them.

A further problem in installing a new instructional technology program is the resistance of teachers and local administrators who often believe they would be disadvantaged or inconvenienced by it, or who fear that the untried programs may be worse than the present one. Teachers do not take kindly to innovations which they fear would down-grade their profession or threaten their jobs and this is probably just as true in countries experiencing an extreme teacher shortage as anywhere else.

Moreover, educational administrators usually lack the time and/or the planning expertise to bring about a major instructional change. They do not, therefore, introduce instructional technologies at all or they do it in insignificant ways that do not increase student-teacher ratios or reduce the number of fully trained professional teachers needed. Or a restricted experiment may be tried which proves meaningless for real innovative change. Under these circumstances, the long-range potential of instructional technologies for greater cost-effectiveness cannot become apparent.

14.2 Levels and subsystem or subsystems involved in this study. The levels are the society and the organization. The chief subsystems are the producer, which builds and repairs school buildings; the supporter, which maintains them; the transmitter, channel, and receiver components of the channel and net subsystem which transmits educational information; the associator subsystem, where the learning goes on; the memory subsystem that stores instructional information; and the decider subsystem that determines policy.

14.3 Existing relevant research. The research of March and Simon on the resistances to organizational innovation is highly relevant.[1] Also the studies by Woodward on introduction of change into industrial organizations apply to educational systems.[2] She found that even in firms in which management was progressive and employees appeared ready to accept change, innovations were not implemented smoothly. Two problems appeared in every firm studied: the initiation of change was extremely slow and, no matter how carefully the idea was introduced, opposition was the immediate and almost automatic response of subordinates, both supervisors and operators. The resistance to change found in this study was greatest in the most successful secure workers, the elite of the labor force who would have had no trouble getting other jobs if they had chosen to do so. They used the change as an occasion for bargaining either for a reduction of effort or an increase in wages. Resistance finally diminished when terms were agreed upon. A similar bargaining process took place over the distribution of power at middle management and supervisory levels. These people were determined to get something out of the change and, like the workers, these managers and supervisors also insisted upon gaining, either by increasing their relative power positions or by making management conscious of the critical role they played in the change. All this resulted in their receiving better performance ratings and higher salaries.

The literature on spread of innovations through societies, such as the well known work of Rogers, is also relevant.[3]

14.4 The research design. This study would take place in two phases.

Phase I, one year. A management research team that included an expert in educational technology, an educator, an operations research, and a communications engineer would be sent to a less developed country that wished to introduce instructional technology into its educational system. This team would familiarize itself with current state of the educational system. They would concern themselves with the present budgets, the problems faced by the teachers and the administrators responsible for the system, and the number of schools or other educational programs included in it. They would also investigate the special problems of the country in relation to education, such as extremes of climate, transportation difficulties, economic weakness, or internal dissention. Then they would recommend a ten-year plan for the country's educational system, including a detailed budget which indicated how it would be feasible and economically practical to phase in widespread use of instructional technology, if that appeared desirable.

This plan would represent the optimal mix of possible solutions, some of which are as follows:

- Since the initial costs are probably the greatest obstacle to starting innovative systems in less developed countries, borrow money or obtain a grant. El Salvador, for example, obtained a loan from the United States to help it initiate its instructional TV program at the seventh through ninth grade levels.
- Temporarily cut the budget for new school building construction and repair (producer subsystem processes).
- Temporarily cut the budget for some other less crucial part of the national economy (a decision to be made by the country's decider subsystem).
- Take advantage of normal turnover to replace employees that will not be necessary in the new system with equipment, technicians, or trained paraprofessionals to function in the new system.
- Take advantage of the growth in demand for education that exists in most less developed countries, meeting it with technology rather than trained teachers.
- Use only technologies that increase effective student-teacher ratios (often mass media employing components of the channel and net subsystem).
- Instead of adding teachers, add paraprofessionals and technicians who are paid less and use media to present curricular content.

- Profit from advantages of scale by using mass media for the entire country or even share media when feasible with other countries, coordinating activities by electronic networks, rather than relying solely on independent instruction in individual classrooms.

- Have instructional information transmitted over mass media electronic channels and nets instead of transporting teachers, books, and equipment over the distribution network, which can be more expensive and less reliable.

- Improve centralized planning of the decider subsystem by using a computerized management information system to increase cost-effectiveness.

Phase II, six months. If the proposed plan were accepted--perhaps with modifications--by the officials of the host country, Phase II would be undertaken if they should wish it. It would be directed toward decreasing probable resistance to the new plan by a public education program to explain it and facilitate acceptance of it by administrators, teachers, parents, students, and the general public.

14.5 Staffing and scheduling. The entire study could be carried out by an instructional technologist, an operations researcher, and a secretary, who would work throughout the two phases. As indicated above the schedule would be as follows:

1. Phase I, one year. Recruiting personnel, planning the study, collecting data, and writing the report recommending the new instructional plan.

2. Phase II, six months. Contingent upon approval of the report, public education program directed to acceptance of the new plan.

14.6 Steps required to translate findings into operational use. Discussion of the plan with educators and public officials while it is being prepared and after the report is written. Also the public education program of Phase II.

14.7 Coordination with other research and development work. The findings about resistance to innovation, and ways to circumvent it, which come from this study should be related to other studies on this topic like those mentioned in Section 14.3 above. The findings of this study would relate to several other projects we propose herein, which involve introduction of new instructional programs.

14.8 Professional expertise required. An expert in instructional technology and an operations researcher.

14.9 Estimated costs. A total of 4.5 man-years and the monetary expenditures indicated below:

| | | |
|---|---|---|
| Phase I, one year. | 36 man-months | $ 72,000 |
| Phase II, six months. | 18 man-months | 36,000 |
| TOTAL | 54 man-months | $108,000 |

14.10 Appropriate countries for project. Vietnam, Ethiopia, and Malaysia.

## References

1. March, J. G. & Simon, H. A. Organizations. New York: Wiley, 1958, 173.
2. Woodward, J. Industrial organization: theory and practice. London: Oxford Univ. Press, 1965, 192-195.
3. Rogers, E. M. & Shoemaker, F. Communication of innovation: a cross-cultural approach. New York: The Free Press, 1971.

## 15. Proposed Project 15, Priority B

## ALTERNATIVE CONFIGURATIONS OF AUDIO CHANNELS, INSTRUCTIONAL MATERIALS, AND TYPES OF FEEDBACK

This is a study of the comparative cost-effectiveness of 18 alternative configurations of audio channels, instructional materials, and types of feedback for the educational systems of particular less developed countries.

15.1 Objectives. The objective of this study is to carry out management surveys and develop a computer simulation to assist educational planners in selecting the instructional system with the greatest cost-effectiveness for their country.

The choice among alternative educational technologies is often made in unsystematic fashion with the result that the chosen system fails to maximize cost-effectiveness. Selection should take into account not only the range of available technologies but the geographical and climatic conditions of the country, the resources of money and personnel available, and the existing communications network.

Educational broadcast systems have three indispensable parts: a channel or network, instructional materials to be used in conjunction with the program presentation, and a provision for feedbacks to the students on their attainments and to the teacher making the broadcasts about the effectiveness of the lessons. Each of these can be provided in a number of different ways. In this research we shall consider: (a) audio channels or networks of three sorts--FM radio multiplexed channels, satellite channels, and telephone lines; (b) instructional materials of several sorts--programmed instruction delivered in various ways and other written materials, also delivered in various ways; (c) feedbacks which may be sent by mail, provided by teaching machines, or sent over telephone lines by document facsimile transmitters. These feedback processes differ in how immediately they provide feedback, from the mails, which are slowest, to the teaching machines, which are fastest.

This project would attempt to determine the most cost-effective combination of these elements for the social, economic, and physical conditions of particular less developed countries.

15.2 Levels and subsystem or subsystems involved in this study. The levels are the organization and the society. The subsystems are the three components of the channel and net subsystem, the decider subsystem, the associator subsystem, and the memory subsystem.

15.3 Existing relevant research. New developments in radio transmission technology have made feasible several alternative transmission systems. If radio is to fulfill major instructional functions, providing two-way communications between students and teachers, multichannel radio is very desirable or, indeed, essential. The potential of traditional shortwave broadcasting has been greatly enhanced by the development of FM radio "multiplexing."[1] FM stations can "piggy back" up to four subcarrier AM channels on the main FM carrier wave. This appears to be the most feasible way to develop multichannel terrestrial broadcasting. Four multiplexed transmitters used simultaneously, for example, would make

20 channels available, so permitting ten radio courses with feedback to be given in a system simultaneously, or numerous other combinations of audio and other instructional media. Multiplexing is capable as well of carrying other media besides audio, for example, document fascimile transmission, telewriting, and slow-scan television. Ordinary short-wave receivers cannot receive multiplexed signals without an adapter which presently costs about as much as a radio.

A considerable amount of research has been done on multichannel radio delivery by communications satellites (see pages 170 to 172). Jamison, Jamison, and Hewlett analyzed the cost advantages of radio over TV while working as consultants to Project SACI in Brazil.[2] Radio costs perhaps a tenth to a twentieth as much per channel as TV. Jamison made cost estimates based largely on a design study, MISSAC, conducted at the University of Michigan for a 30-channel instructional radio system.[3]

15.4 The research design.

Phase I, one year. In this beginning period of the project management studies will be made of three countries to determine a range of facts about physical, economic, and social variables relevant to the selection of an instructional system. These would include geographical and climatic variables; size of country; resources of money and personnel; cultural variables that appear relevant; language distribution; intensity and diversity of expected uses of the educational system; existing communications facilities; and possibility of sharing facilities for transmission of educational programs with another country.

On the completion of these studies an effort would be made in each country to determine the best instructional system for it. The investigator's attention would be addressed to the 18 combinations of communications technologies, instructional materials, and feedback methods presented in the following matrix:

| | Multiplexed FM | Satellite | Telephone Lines |
|---|---|---|---|
| 1. Audio instruction only | | | |
| 2. Audio instruction with audio feedback | | | |
| 3. Audio instruction with mail feedback | | | |
| 4. Programmed instruction with audio instruction | | | |
| 5. Programmed instruction with two-way audio | | | |
| 6. Programmed instruction with audio instruction and mail feedback | | | |

Three of the most important communications technologies, or channel and net artifacts, which can be used in instructional systems are shown in the three vertical columns above. There are six instructional modes in the horizontal rows, three employing audio instruction without any additional instructional materials and three employing audio instruction along with printed programmed instruction workbooks given to each student. It is assumed that the studio teacher would present all the content material when no workbooks were used, but that the workbooks would provide content when they were used in conjunction. It is also assumed that teachers or paraprofessionals would be in the classroom with the students to supervise their activities, administer and correct tests from answer keys, and provide whatever help they could, but they would not be expected to be experts in content.

In Condition 1 there would be only one channel audio instruction with no feedback to the teacher from the classrooms. In Condition 2 there would be two channels so such direct and rapid feedback would be possible. In Condition 3 the teacher or paraprofessional would grade examinations from answer keys and answer students' questions as best he could. Other questions would be answered by mail and the studio teacher would learn by mail--a slow feedback method--of the students' examination performance and their reactions to the course. In Condition 4 programmed instruction workbooks, which are expensive to print and to distribute, would be used with audio instruction. Condition 5 would be the same except that there would be audio feedback. Finally, in Condition 6 there would be workbooks, audio instruction, and mail feedback like that in Condition 3.

For each of the 18 combinations in the above matrix information will be secured concerning the costs of purchasing equipment, installing it, and operating it; its performance characteristics; the necessary qualifications of the classroom teacher or paraprofessional who would use it; the number of man-months of programming effort required to prepare the instructional materials; the costs of printing them; the demands made upon the media teacher; and the technical skills required to operate and maintain the system.

Phase II, one year. In the second year of the project, a computer program would be prepared and tested. All the data secured for each of the countries, as well as for each of the 18 cells of the matrix, would be input to this program. On the basis of these calculations, a final report with recommendations would be made to educational planners of each country concerning the cost-effectiveness of each of the combinations for their particular country. Efforts would then be made to assist each country in implementing whatever instructional system it might select.

15.5 Staffing and scheduling. In each country there would be a director who was an instructional technologist and an associate director who was a communications engineer. One of these might come from that country but the other should probably come from abroad, bringing expertise not available locally. There should also be a computer programmer and operator, a data analyst, and a secretary. The director of the team in one country should also be the overall head of the project.

As indicated above the phasing of this two-year project would be:

1. Phase I, one year. Recruitment, planning, and data collection.
2. Phase II, one year. Preparation of computer program, data analysis, writing of final report, and beginning implementation of any instructional system selected.

15.6 Steps required to translate findings into operational use. First local authorities would have to review the final report with the project staff and then decide on what future instructional system they would use. The staff could then assist them in obtaining the necessary personnel and equipment and establishing a detailed plan for implementation on a regional or nationwide basis.

15.7 Coordination with other research and development work. Research on audio media and programmed instruction has been discussed in several other parts of this report. All this is relevant to this project.

15.8 Professional expertise required. Experts in instructional technology, communications engineering, computer programming, and data analysis.

15.9 Estimated costs. Thirty man-years of activity for the entire project, 10 in each of three countries. The costs, by phase:

| | | | |
|---|---|---|---|
| 1. | Phase I, one year | 180 man-months | $360,000 |
| 2. | Phase II, one year | 180 man-months | 360,000 |
| | TOTAL | 360 man-months | $720,000 |

15.10 Appropriate countries for project. Indonesia, Guatemala, and the Philippines, all of which are in need of national educational systems of good quality which they can afford and which they can implement despite a shortage of trained teachers.

## References

1. Bretz, R. A taxonomy of communications media. Englewood Cliffs, N. J.: Educational Tech. Pub., 1971.
2. Jamison, D., Jamison, M., & Hewlett, S. Satellite radio: better than ETV. Astronautics & Aeronautics, 1969, 7, 92-96.
3. Kurland, J. R. & Tomei, E. J. Radio instruction via direct broadcast communication satellite. IEEE International Conf. on Communications Conf. Record, 1968, 562-565.

## 16. Proposed Project 16, Priority B

## TELECOMMUNICATION VS. LAND DISTRIBUTION

This is a study comparing the cost-effectiveness of celestial, terrestrial, or mixed educational telecommunications with land distribution of audio and video tapes, films, slides, or books, for formal and nonformal education in rural areas.

16.1 Objectives. The objective of the proposed research is to provide a detailed study of the comparative costs of physical distribution of audiovisual teaching materials and use of telecommunications as instructional media.

The arguments that are currently used in justifying the costs of telecommunications in educational systems make important unverified assumptions. They tend to eliminate alternatives without sufficient study. It is important to undertake a thorough examination of the various alternatives before a commitment to one is made.

Five commonly used arguments in favor of use of telecommunications are as follows:

1. Physical distribution systems, whether by mail, by boat, or by special carriers, are unreliable in many less developed countries. They cannot be counted upon to deliver material for programs.

2. If a high enough proportion of a population to be served owns or has access to receivers or terminals, physical distribution of instructional materials cannot compete in costs.

3. If costs and availability of trained instructors constrain expansion of an educational system, telecommunications--particularly TV--are more effective than books, films, and slides in extending the amount and quality of instruction that can be delivered.

4. Less developed countries can be expected to invest in telecommunications systems of some kind whether or not they are used for education, and there could not be a better use for them than education.

5. Public education of illiterate or poorly educated adults is of the utmost importance to less developed countries. Telecommunications have advantages over other media in reaching and meeting the needs of such people.

16.2 Levels and subsystem or subsystems involved in this study. The society and the organization (schools and communities) levels are involved. The subsystem is the channel and net, all three components.

16.3 Existing relevant research. A study by Schenkkan[1] indicates that television's advantage over film and video tape lies in economies of distribution. Further studies by Ohlman[2] show that costs of producing sufficient prints and bringing them, together with projectors or players, at the right time and place are high enough to preclude their use on the scale necessary to meet the needs of educational systems.

In another study a panel simulated a hypothetical country having an area of one million square miles and a population of seventy million dispersed over 20,525 cities and towns: 1 of 5,000,000; 8 of 1,000,000 (500 miles apart); 16 of 100,000 (250 miles apart); 500 of 10,000 (50 miles apart); and 20,000 of 2,500 (7 miles apart).[3] The environment was that of a less developed country which had few paved roads, sparse terrestrial communications except in the major cities, primitive or second-class airports in the 16 largest cities, no trained personnel, and few maintenance facilities.

The information could be distributed in two ways: (a) by transmitting to 20,000 locations for group viewing, or (b) by transmitting to 1,000,000 locations for group or single family viewing. In both instances there would be variations in the number of people viewing the programs, and in distances the viewers traveled. Table 12 contains basic cost data on information distribution for five terrestrial and three satellite support communication systems.

The distribution systems used in Table 12 are as follows: In the automotive/aircraft distribution system all the television tapes are produced in one city and delivered by a C-140-type cargo aircraft to 16 of the country's largest cities. Each city uses small planes, such as Piper aircraft, to drop the tapes to an average of 60 pickup points, and motor vehicles are then used to deliver them to 20,000 towns and villages where they are displayed on one video screen in each population center. The tapes are recycled daily to provide 12 hours of programming each day for the viewers. The aircraft distribution system produces and delivers the tapes in the same fashion as above, but with the exception that smaller aircraft are used to deliver the tapes directly to the towns and villages. In the airborne distribution system the tapes are produced in the same manner, but aircraft from seven centrally located airports fly broadcast patterns at seven locations and broadcast to receivers via UHF and VHF for 12 hours a day.

| Distribution System | Number of Users | Annual Cost of Display $ | Annual Transmission Costs $ | Total Program Annual Cost $ *** |
|---|---|---|---|---|
| Aircraft distribution tape | 20* | 618,700** | 54,300 | 673,000 |
| Aircraft and auto distribution tape | 20 | 618,700** | 37,300 | 656,000 |
| Terrestrial and 25 broadcasters | 1,000 | 71,700 | 189,300 | 261,000 |
| Terrestrial and 200 broadcasters | 1,000 | 71,700 | 76,200 | 147,900 |
| Airborne broadcasting | 1,000 | 71,700 | 25,300 | 97,000 |
| Satellite with 200 receivers (distribution) | 1,000 | 71,700 | 60,300 | 132,000 |
| Satellite with 70,599 receivers (community broadcast) | 1,000 | 71,000 | 17,300 | 89,000 |
| Satellite with 1,000,000 receivers (direct broadcast) | 1,000 | 71,700 | 51,300 | 123,000 |

* All numbers should be interpreted in thousands, e.g. 20 = 20,000.

** Includes annual costs for television tape.

***Annual costs are the sum of depreciation, amortization, maintenance and operation costs expressed in 1967 dollars. Capital costs are assumed to be zero.

Table 12. Economic Comparison of Program Alternatives

(Adapted from Broadcasting, 1969, 10, 72. Prepared by the National Academy of Sciences for the National Aeronautics and Space Administration, Washington, D. C.)

The first terrestrial system uses microwave to interconnect cities having populations of 10,000 or more. Information is broadcast over a 50-mile radius from the 25 largest cities by UHF and VHF stations. Coaxial cable is used for distribution to the remaining cities. The second terrestrial system is the same as the first with the exception that 200 of the cities with a population above 10,000 rebroadcast by conventional UHF and VHF facilities.

The first satellite system is a distribution system in which information is transmitted from a central transmitter by a satellite to 200 regional locations where the information is transmitted by conventional UHF or VHF receivers within a radius of 50 miles. The second satellite system is a community broadcast system. Information is transmitted from a central transmitter by a satellite to 70,599 receivers, some of which are equipped to rebroadcast to cities within a radius of 50 miles. The third satellite system is a direct broadcast system. It transmits information by a satellite directly to 1,000,000 television receivers.

Within the constraints of this study, all satellite distribution systems are more cost-effective than all other systems, with the exception of airborne broadcast. But the second satellite system is cheaper than the airborne system by $8,000,000. While this example is theoretical, it serves to emphasize the possibility of savings through usage of satellite distribution systems.

While most evidence to date favors the utilization of satellite systems for educational purposes, caution should be taken not to represent the system as a panacea, because no operational broadcast satellite systems exist from which definite conclusions can be drawn.

Possibly the real economic advantage of satellite distribution systems will be that they do something new or provide better or hitherto nonexistent services in areas where terrestrial distribution systems are either limited, nonexistent, or else not geared to giving a desired service. Consequently, satellite distribution systems may be justified for use by established and less developed countries on the basis of providing services that could not be offered as effectively by terrestrial distribution systems.

Some countries, including Tunisia, the Ivory Coast, India, Brazil, and El Salvador, have made studies comparing such innovations as (a) adopting educational telecommunications; (b) changing teaching methods; (c) altering the organization of the educational system; and (d) enriching school resources by adding to their equipment. These studies preceded decisions in these countries to develop an educational telecommunications network.

Of course educational satellites appear to have potentially the greatest geographical coverage of any instructional technology. But today no such satellites are in use. There have, however, been attempts to get greater coverage than a ground TV station can obtain.

Airborne television is a possible forerunner of an educational satellite system. The Midwest Program on Airborne Television Instruction (MPATI), managed by Purdue University, was an outgrowth of a Ford Foundation study which showed that the cost of educational television transmission was markedly less than the cost for an equivalent land system. The program showed that airborne broadcasting is effective over a 400-mile circle, and may prove to be a practical means of serving areas intermediate between those which can receive signals from a ground station and those which can receive from a satellite.[4]

16.4 The research design. The country or countries in which this project is carried out must have developed a telephone, radio, or television network which could be used to transmit educational programs. Native educators capable of participating in planning and carrying it out are indispensable. Together with project specialists they would develop programs to be transmitted or would adapt existing programs in use in their own or other countries. The subject areas to be taught should have objective criteria of achievement, as languages and mathematics do. The content of teaching materials to be distributed physically would be identical, insofar as is possible.

It is proposed that 100 schools be selected to receive certain course teaching over the telecommunications network, either television, radio, or telephone, depending upon what networks exist in the country. These would be matched as closely as possible with 100 schools chosen to receive instruction in the same courses from physically distributed materials, either tapes, films, slides, or books. Distribution of materials would not be made daily but weekly or monthly. Matching would be on the basis of distance from the source of transmission, the condition of roads or other distributor components, and the populations to be served. Students in a third group of schools would be taught the same courses by the traditional methods.

The period of the experiment would be three years. At the end of this time an analysis of the descriptive data obtained would be made.

This evaluation would be based on several criteria, among them:

1. The costs of preparing and transmitting or distributing teaching materials, including the costs of providing and installing telecommunications receivers where they are needed and the costs of providing projectors or tape decks where necessary.

2. The percentage of time materials were available when and where needed. Total down-time of television or radio receivers, failure of projectors or tape players, failure of deliveries, and transmission failures would be calculated.

3. Learning of subject-matter by the students in the experimental schools as compared with learning of traditionally instructed students.

16.5 Staffing and scheduling. Except for the consultants, and perhaps the cost accountant and data analyst, all personnel in this project, including the director and associate director, could very possibly come from the host country. During Phase I, the first year, the director and associate director, with a secretary, would work out the experiment in detail, select courses and schools, and supervise preparation of the instructional materials and delivery system, all in closest cooperation with the educational authorities. The experiment itself would go on during Phase II, the second year, and at this time a cost accountant, statistican, and data analyst would be added to collect data on the experiment continually and begin analyzing it. In Phase III, the final six months, all these personnel would continue working together, in cooperation with the operational personnel, to complete a comparative data analysis of the three instructional modes and to write a final report.

16.6 Steps required to translate findings into operational use. For the host country, results indicating which method of instruction is most cost-effective can be applied directly in the regular planning process for development of the national educational system. Applications to other countries could be initiated or facilitated by wide international dissemination of the final report or by international conferences of educators devoted to discussion of the findings.

16.7 Coordination with other research and development work. Findings of this study may indicate directions in which development is needed in a given country. If physical distribution is costly and ineffective, improvement of distributor components may be indicated. If telecommunications seem superior, cheaper means of transmitting signals, such as airborne transmitters or satellites might be investigated more intensively or efforts to produce cheaper TV or radio receivers might be accelerated.

16.8 Professional expertise required. Consultants in telecommunications and in curriculum design and instructional technology, programmers of the various media involved, TV or radio directors and teacher-actors, audiovisual aid production experts, statisticians, cost accountant, and data analyst.

16.9 Estimated costs. In this project it is assumed that the host country will pay all operational costs for preparing instructional materials and operating the three modes of instructional activity. Consultants to help them set up the operations will be provided on project funds, as will all personnel who design the experiment and analyze and interpret the data arising from it.

The project costs, then, would be:

| | | | |
|---|---|---|---|
| 1. | Phase I, 1 year | 36 man-months | $ 72,000 |
| 2. | Phase II, 1 year | 108 man-months | 216,000 |
| 3. | Phase III, 6 months | 36 man-months | 72,000 |
| | TOTAL | 180 man-months | $360,000 |

16.10 Appropriate countries for project. India, Nigeria, Indonesia. Whatever country is selected for the project would have to agree in advance to prepare the course materials (perhaps with consultant aid) and provide instruction in the three modes chosen, and to provide the necessary personnel to operate the three alternate modes of instruction simultaneously for at least one year.

## References

1. Schenkkan, R. *Films versus TV in education*.
2. Ohlman, H. *Communications media and educational technology: an overview and assessment with reference to communications satellites. Report T-71/1*. St. Louis: Washington University, May, 1971.
3. Panel 10. *Broadcasting*, 1969, 10, 68. (Washington, D. C.: National Academy of Sciences.)
4. Schramm, W., Coombs, P. H., Kahnert, F., & Lyle, J. *The new media: memo to educational planners*. Amsterdam: Holland-Breumelhof N.V., 1967.

## 17. Proposed Project 17, Priority B.

## AUDIO CASSETTES, AUDIO TAPES WITH SLIDES, AND VIDEO TAPES

This is a study of formal and nonformal education by audio cassettes, audio tapes, delivered by mail, as compared with traditional teaching.

17.1 Objectives. The main objective of this project is to investigate the cost-effectiveness of some educational technologies which do not require prior development of an instructional mass-media network, as compared to teaching of classes by professionally trained teachers. The instructional systems to be tested can all be sent through the mails or otherwise physically transported to schools, learning centers, or homes. All require electricity. Audio cassettes (Item 18 in Table 7 above) are played on small, easily transported recorder which can be battery-powered. Audio cassettes with slides (Item 13, Table 7) require the same equipment plus a slide viewer or slide projector and screen. This requires more power. Video cassettes (Item 34, Table 7) require a TV set and tape-player but the TV set need not be in a place accessible to TV broadcasts.

Obviously costs of equipment will differ greatly, particularly if the video system is used in a region which does not have TV and therefore has no TV sets obtained for other purposes. On the other hand, a single TV set is all that is required for a class. Maintenance problems and costs can also be expected to vary from system to system.

Less developed countries that wish to increase literacy among the adult population and to improve the quality of instruction offered to children in their schools are, of course, often seriously handicapped by lack of well-trained teachers. Mass media instruction has been developed in some countries to supplement instruction by teachers and paraprofessionals. This is an effective method of teaching where the necessary networks are present. Traditional TV instruction is not, however, cost-effective in very remote areas where populations are small and TV relay stations could not be installed without high expense.

Teaching by cassettes has a number of advantages over broadcast instruction: It is available at any time selected by the class or individual student; or parts of lessons can be repeated at will; and once delivered, cassettes can be played hundreds of times for different classes.

Each of the three instructional systems to be compared with traditional teaching has advantages over the others. Audio cassettes are cheaper, simpler to use, and less susceptable to breakdown. Audio cassettes with slides cannot present programs with branching (see page 159) but have the added visual input. Video cassettes with their two sensory modalities may be more interesting to students, although there is question about this (see page 164), and may be more reinforcing for this reason.

It is important, since these media have much promise, to determine their cost-effectiveness when they are used in less developed countries by people who may be inexperienced in the use and care of electronic equipment.

17.2 Levels and subsystem or subsystems involved in this study. Three levels are considered, the group, the organization, and the society. All three components of the channel and net subsystem--transmitter, channel, and receiver--as well as the associator subsystem, are involved.

17.3 Existing relevant research. About 15 years ago the United States Department of State evaluated audio tapes and decided that this was the best method available at that time for the American Foreign Service Institute to teach foreign languages to foreign service personnel. The successful experience of commercial enterprises, such as Berlitz, with these devices is also relevant.

Combined audio and slide systems have also been studied. System 80 by Borg Warner, for example, is a set of programs designed to be used by children working alone and by children with special learning problems.[1] Its advantages over traditional methods of teaching have been demonstrated in studies on reading with the public schools of Erie, Pennsylvania; on arithmetic in the public schools of Chicago; and on reading in another school system. A different audio and slide program, the Michigan Language Program, which teaches literacy in English to primary grades, retarded children, adults learning English as a second language, and illiterate adults, has been tested experimentally.[2] Not only did children attain a high degree of proficiency in the subjects offered, but they worked well and sustained interest in the task.

Video cassettes are sufficiently new that evaluative educational research has not been carried out.

17.4 The research design. One hundred secondary school students and one hundred adults would be assigned to one of eight experimental groups:

1. Traditional teaching, secondary school.
2. Traditional teaching, adult.
3. Audio cassette, secondary school.
4. Audio cassette, adult.
5. Audio tapes with slides, secondary school.
6. Audio tapes with slides, adult.
7. Video tapes, secondary school.
8. Video tapes, adult.

The subject-matter would be the same in all conditions. Only the manner of presentation would be varied. Beginning science, literature, poetry, or other courses could be used. Programs would be written or adapted so that no auxillary printed material was necessary. Students in all eight conditions would use pencil and paper only in writing answers, taking tests, or doing calculations.

The traditional teaching would be done in an ordinary classroom by the teachers usually assigned to the grade or to the adult education classes concerned. These classes would necessarily meet together at stated times during the school day, or at adult education periods in the evening.

The classes using cassettes, however, would meet together for the initial instructions and for testing periods but would have freedom to receive instruction in smaller groups, or even individually, according to schedules acceptable to them and to the school administration. A teacher would be in charge of the course but would not necessarily be present during the instruction. He or she would, however, be available for assistance, answering questions, and conducting tests. These groups would not always have to meet in the same place, unless that was required for access to a television set.

Measures of costs would include the expenses of preparing the programs; costs of the cassettes, TV sets, and other electronic equipment required; shipping, mailing, or other transportation costs; teachers' salaries; costs of repairs and replacements of equipment; and costs per student hour for classroom space occupied.

Measures of effectiveness would include pretests on the subject-matter of the course and monthly tests during the period of the experiment and at its end. They would measure achievement by students during the experimental period. In addition, records would be kept of the number of students who began the course, the number who finished, and the number who dropped out; the amount of time learning could not go on because of equipment failure; and the reasons for failure if these could be determined. In all conditions, students would be asked to discuss their satisfaction with the course and requested to suggest modifications. The number of students who expressed satisfaction and who were dissatisfied would be determined.

A cost-effectiveness ratio would be derived on the basis of all these measures.

*17.5 Staffing and scheduling*. A project director and an associate director, one of whom is an expert on educational technology, a secretary, and a data analyst would be required. Repairs of electronic equipment would be carried out by technicians in the country.

*Phase I, one year*, would be devoted to developing instructional materials and preparing cassettes. The schools or adult education programs invited to cooperate in the project would be selected. The project would be explained to the administrators of these schools and programs. Teachers who had not previously used the sort of equipment required in the project would be taught to use it and given a period of familiarization with it before use of it for the project began and experimental classes were selected or formed.

*Phase II, one school year*. This would be the experimental period.

*Phase III, six months*. This time would be devoted to data analysis and writing of the final report.

*17.6 Steps required to translate findings into operational use*. Findings would be applicable to any less developed countries seeking to select educational technologies for use in their schools. Therefore the final report should be published in journals with international circulation on instructional technology and reported at conferences of educators.

*17.7 Coordination with other research and development work*. Results of this project would add to the store of work evaluating various educational media. The findings could be compred with findings for other media.

The research work cited in Section 7.3 above involves schools in the United States. The proposed project would provide cross-cultural comparisons.

17.8 Professional expertise required. Experience in educational technology, experimental design, curriculum planning, project management, test development, and data analysis would be the chief professional requirements.

17.9 Estimated costs. The labor involved would total about 12 man-years. The costs:

| | | | |
|---|---|---|---|
| 1. | Phase I, one year. | 60 man-months | $120,000 |
| 2. | Phase II, one school year. | 54 man-months | 108,000 |
| 3. | Phase III, six months. | 30 man-months | 60,000 |
| | TOTAL | 144 man-months | $288,000 |

17.10 Appropriate countries for project. Nepal, Niger, and Colombia.

## 18. Proposed Project 18, Priority B

## EDUCATION BY AN INTERNATIONAL SATELLITE VS. TRADITIONAL EDUCATION

This is a study comparing formal and nonformal education using an international educational satellite, with traditional education.

18.1 Objectives. One of the best ways to improve the quality of education and cuts its costs is to share resources among several instructional activities. All the teachers of Spanish in a school can cooperate in preparing curricular materials and presenting courses, or a whole school system can arrange radio courses in science and mathematics, or an entire country can cooperate in TV literacy training for adults. This project is an examination of the issues involved in extending this general principle internationally. Tourists, imports and exports, the mails, cables, telephone calls, TV programs--all cross national borders routinely today. Why cannot various sorts of instructional materials? Why must lectures, textbooks, educational radio and TV programs, CAI and CMI, and other instructional materials be prepared for only one organization or nation? Of course the materials often must be translated to other languages and adaptations must be carried out to make them relevant to specific nations and situations. Of course some subjects are emphasized in certain countries and neglected in others. But there still is much commonality in instruction from one nation to another.

The prime objective of this study is to determine ways that are politically and educationally feasible to share formal and nonformal instruction by educational satellite among established and less developed nations.

18.2 Levels and subsystem or subsystems involved in this study. Three levels--the organization, the society, and particularly the supranational system, and the three components of the channel and net subsystem--the transmitter, the channel, and the receiver--are involved.

18.3 Existing relevant research. In many parts of the world, including numerous less developed countries, innovative educational experiments employing instructional technologies are under way. They have a common theme of employing mass media for formal and nonformal instruction of children and adults who would not be able, or have not been able, to receive quality instruction by other means. Often certificates, diplomas, or other recognition of achievement useful for obtaining jobs, promotions, or greater social recognition are given to students who successfully complete such training. All these experiments are relevant to the project we prepose because they could potentially be extended across national borders by an international channel and net using a satellite. We list below a few of these experiments:

- Open universities, colleges, and high schools. Since January, 1971, students have been attending Britain's Open University. Chartered like the traditional universities of the United Kingdom, it is an integrated system of home-based, university-level education employing written material programmed for self-instruction; television and radio programs transmitted by the British Broadcasting Corporation on Sunday mornings and between 5:30 p.m. and 7:30 p.m. on weekdays; student assignments, some of which are graded by computer and others by part-time tutors; a network of more than 250 local student centers, usually in technical colleges or schools;

part-time tutors for face-to-face instruction; summer schools within a traditional university setting for all students; and in science a kit costing $300, for lab experiments in the home. Possibly none of the individual components is novel. But the combination of the components into an overall system is new.

The British Open University has arranged through the College Entrance Examination Board for trials of its instructional materials in four universities in the United States. Discussions are also going on concerning the extension of the Open University to Bermuda and to countries in the European Common Market. Indeed, persons from almost every major nation in the world have approached the Open University to discuss the possibility of sharing its plans and resources.

Certain other countries have or are planning oper universities. There is a Televisão Universitária in Recife, Brazil. Conducted by the Channel 11 television station, it was inaugurated in November, 1968 and is sponsored by the Federal University of Pernambuco. The TV Universitária attempts to advance cultural and artistic development through programs for home reception, and to educate specific groups through courses for organized reception. Recently it entered into an agreement with the Organization of American States to create a multinational program of tele-education. Also a preparatory study committee in Japan in 1970 recommended the establishment of a Japanese University of the Air. It is expected that it will begin operations in 1973.

Among the open colleges or high schools now in operation are the following: the NHK Gakuen (High School) or Tokyo, begun in 1963, which serves all of Japan; the Bavarian Telekollegg, begun in 1967, which undertakes to provide courses of instruction leading to grade or technical school diplomas; the Kenya Radio-Correspondence Program for teachers, which begun in February, 1968; the Television Technical College of Poland, which began full operations in 1966 to supplement the correspondence study of students taking the first two years of technical school; the Television Academy of the German Democratic Republic, which provides a variety of courses for adult education; the USSR's Broadcast Study Courses, which are transmitted from stations in at least 35 cities in the Soviet Union for both formal and nonformal education and have been in operation at least since 1966; and the Chicago College, begun in 1956 by Chicago City College, which provides opportunities to study a standard two-year curriculum for credit.

- Sesame Street and the Electric Company. The Children's Television Workshop first put on the air "Sesame Street," their program for teaching letters and numbers to preschool children, in 1968. Already, four years later, shown in every English-speaking country in the world, it is being produced in Spanish in Mexico, in Portuguese in Brazil, and in German in West Germany. The "Electric Company," the TV program, created by the same group, which is designed to teach readings, was first broadcast in 1971 and is likely to spread similarly to other countries in the near future.

- Indian satellite. The United States government expects in 1974 to launch an ATS-F satellite (Applied Technology Satellite-F) into a stationary orbit over the equator in the region of the Indian Ocean (see page 318). At first it will be oriented to broadcast to Alaska, the Rocky Mountain area, and Appalachia. After six to nine months devoted to various educational and other experiments with the satellite in that position, its orientation will be changed so that its "footprint" covers essentially the entire Indian subcontinent. From 1974 on, for the lifetime of the satellite, it will be available to the Indian government for educational and other uses.

Among the experiments to be carried out in the Rocky Mountain area next year is one employing 500 aluminum antennas, ten feet in diameter. Each of these, when connected through a "front-end converter" to a television set operated with either regular electric current or batteries, can receive directly from the satellite. These antenna-converter-TV set combinations can probably be mass-produced, even in some less developed nations, for less than $1,000 a unit--perhaps as little as $200 in large quantities.

In recent years the Indian government has set up several educational television stations and is planning to employ instructional materials such as they use on the ATS-F satellite. They expect to use the satellite for English adult nonformal education, literacy, family planning, and occupational training. The satellite program was under the direction of Dr. Vikram Sarabai, former head of the Indian Space and Atomic Energy Agencies. It suffered a serious blow when he died in December, 1971. The program probably will now come under the control of the Ministry of Information and Broadcasting. Plans for preparing instructional materials and producing adequate numbers of television sets, antennas, and other necessary hardware to meet the vast educational needs of India are moving forward very slowly. Experts in other countries have been approached by the Indians, but planning and implementation of the program are lagging.

- Brazilian satellite. There appears to be much more active and integrated planning for the educational use of satellites under Project SACI in Brazil (see pages 310 to 312). The main figure in this activity is Dr. Fernando de Mendónca, General Director of the Brazilian Space Agency. He hopes to be able to make at least some experimental use of the ATS-F satellite, either when it is in position for the American experiments, or when it is in position for India, or both. In order to obtain predeployment experience he has used another satellite to provide two-way live television conferences between Stanford University and the Brazilian Space Agency at São José dos Campos. He has also experimented with the use of the latter satellite to provide teletype access to MEDLINE, a medical bibliographical service of the National Library of Medicine in Washington. Furthermore, he has underway a predeployment television experiment in the state of Rio Grande do Norte in northeast Brazil. Beginning in October, 1972 six months of teacher training by television and/or radio will be offered to primary school teachers in this state. In 1973 instruction by radio and/or television will be provided on an experimental basis to school children in some areas of the state. The relative advantages of the different media will be evaluated, as compared with traditional educational procedures, by either trained or untrained teachers. An experiment is planned to use the ATS-F satellite as a communications link to convey some of these television and radio programs. Sometime by or before 1976 the Brazilians plan to arrange for the United States to deploy their own domestic educational television satellite, by which they have to provide education to even the most rural and primitive parts of Brazil. They expect to pay a major portion of the cost of this themselves. It is their hope that formal and nonformal educational techniques like those planned for Rio Grande do Norte can then be used throughout Brazil.

- Primary and secondary instructional television. El Salvador began a program of school reform in 1968 after intensive examination and evaluation of the country's educational problems. The purpose of the reform was to make new and better things happen in the classroom--for the benefit of both the student as an individual and the society. The program was built around educational television, with funds and technical assistance provided by AID. Details of it have been presented above (see pages 182 to 186 and 281 to 284).

The first intensive use of television for all grade levels begin in American Samoa in 1964. It was planned as part of a complete educational reform, at first with a highly innovative spirit. In recent years it appears to have developed rigidities of practice which may limit its usefulness.

The Ivory Coast began in 1971 a ten-year project intended ultimately to encompass the entire school population and become the most complete and systematic use of educational television yet undertaken. Television also has been used in an exploratory way in Niger, with particular emphasis on extensive student participation. It has also, since 1963, been used in the classrooms of Colombia where it is now reaching about 500,000 students, more than any other such program anywhere. The Mexican Telesecondaria, begun in 1968, provides secondary school education in towns and villages which have no secondary schools. There have also been experiments in India.

Numerous projects are planned or underway in various states of Brazil, including Guanabara, Paraná, Pernambuco, São Paulo, Marinhão, Rio Grande do Norte, Rio Grande do Sul, and Minas Gerais. Brazil has seven operating educational TV stations and plans are being made to interconnect them and to inaugurate others.

Within the last year Malaysia, an improverished, developing nation, has received 5,500 television sets for instructional television, purchased for them by a German foundation. They expect to receive 4,500 more in coming months, for a total of 10,000. The details of how they will use these sets have not yet been worked out. Singapore is actively using educational television for specific courses for school children in learning centers.

At the Center for Educational Television in Manila, in the Philippines, Father Leo H. Larkin has developed a program of instructional television courses for students from first grade through high school. Teachers' guides and students' workbooks coordinated with these telelessons are provided. The television programs are transmitted either through closed circuit television, which reaches two neighboring colleges, by 2500-megahertz systems which cover schools within a 20-kilometer radius, or by open broadcasts through an educational television channel that sends its signals well beyond greater Manila. The courses teach the local Filipino language, English, socioreligion, music, art, geography, general science, biology, and physics.

Extensive plans have been underway in Korea for a complex multi-medium approach to educational reform in elementary and middle schools. This program will include a number of reforms, such as changing the basic instructional unit from its present class size to a larger grouping, introducing individualized instructional concepts and associated materials prepared on the principles of programmed instruction, modifying the role of the teaching staff to that of management of the learning environment, increasing the ratio of students to teachers, and using programmed instructional television and radio. Continual appraisal and evaluation are built into the planning.

In Australia radio-correspondence teaching began in 1933 and schools of the air to provide primary and secondary education where it is not available locally, as well as to prisoners in jail, began in 1951.

And finally, plans are just beginning to be made to reform educational activities in Guatemala in ways which may involve mass media.

18.4 The research design. This project would be an operational experiment providing instruction by satellite to at least three countries simultaneously and comparing the cost-effectiveness of comparable instruction by traditional means in those same countries. The nations participating in the project should have a large number of students capable of using the same language and it should be a language in which full courses of tested instructional materials are available. Two obvious languages are Spanish and English. Spanish might be used in Spain and any Latin American country except Brazil--say Spain, the Dominican Republic, and Nicaragua. English could be used in Iran, Pakistan, and Lebanon for the many college level students there who speak that language.

Phase I, 18 months. At least 1,000 seventh grade (or equivalent) students would be assembled in each of three countries (Spain, the Dominican Republic, and Nicaragua). They would be divided randomly into two sets in each country, half to receive for one academic year traditional seventh grade education, in classes with teachers, in science, mathematics, and English as a second language; the other half to receive the same education for the same period of time by satellite transmission of the El Salvador TV tapes on these subjects, in classes supervised by paraprofessionals. The two sets of students would be compared on pretests, periodic tests during the courses, and posttests. Also the grades of similar students immediately in previous years would be obtained. Careful accounting would be made of all costs of the instruction (even though, of course, satellite transmission for such an experiment with only a few hundred students would be very expensive.) Student, teacher, and paraprofessional attitudes toward the satellite instruction would be investigated.

(An alternate to the above study with seventh grade instruction in Spanish would be a similar experiment using British Open University instructional materials in English with comparable numbers of English-speaking college level students in Iran, Pakistan, and Lebanon.)

Phase II, one year. The data and observations made during either the Spanish language study or the English language study would be analyzed in order to determine the feasibility and cost-effectiveness of such international sharing of educational resources. If it appeared practical to use such methods and to extend them to other nations, the findings would be called to the attention of the international educational community and the policy making-officials with whom they worked.

18.5 Staffing and scheduling. The overall project would need a director and associate director, one an expert in instructional technology and the other an expert in satellite technology. There should also be a staff member experienced in diplomatic discussions designed to elicit international cooperation. (This is important in this project because of the central significance of educational policy to most nations and the fear of some less developed countries today that satellites may become instruments through which other nations can indirectly exercise control over them.) The central staff also would need two secretaries.

Each participant country would have to provide from its own funds personnel to operate their ground satellite receiving station or stations, TV transmission facilities, and educational institutions. The project, however, should have an educator and a secretary, probably local citizens, in each host country to select the two sets of students, arrange for the testing, and obtain the other data required for the comparative evaluation of the traditional and satellite instructional programs.

18.6 Steps required to translate findings into operational use. The findings should be discussed with local educators and officials as they are being analyzed. When the final report is completed, if international satellite education seems promising, the findings should be given wide international publicity and funds should be sought to establish an experimental international educational system employing such instructional media.

18.7 Coordination with other research and development work. Several instructional media can be transmitted by satellite or otherwise used internationally. Therefore all research on these media, and on satellites, is relevant to this project and the project data should be analyzed in terms of these other studies. Most of the many researches on various aspects of international education assume that traditional means of classroom education will be employed. These assumptions should be reexamined in the light of the findings from this proposed project, whatever they are.

18.8 Professional expertise required. Experts in education, instructional technology, educational satellites technology, and international negotiation.

18.9 Estimated costs. The total project human effort over the total 2 1/2 years in three countries, would be 27.5 man-years. The costs, broken down by phases, would be:

| | | |
|---|---|---|
| 1. Phase I, 1 1/2 years | 198 man-months | $396,000 |
| 2. Phase II, one year | 132 man-months | 264,000 |
| TOTAL | 330 man-months | $660,000 |

18.10 Appropriate countries for project. Spain, the Dominican Republic, and Nicaragua; or Iran, Pakistan, and Lebanon, as suggested in Section 18.4 above.

## 19. Proposed Project 19, Priority B

## CURRICULAR MATERIALS AND INSTRUCTIONAL SOFTWARE WITH DIFFERENT CULTURAL AND SOCIOLOGICAL EMPHASES

This is a comparison of a range of alternative forms of curricular materials and instructional software, with different cultural and sociological emphases, for classroom instruction of children and nonformal education of adults.

19.1 Objectives. This study has as its prime objective a formative evaluation of curricula designed to replace the traditional academic programs currently offered in many less developed countries with academic and practical training more relevant to the socioeconomic realities of life in these countries and to the cultures of the peoples.

The subjects taught in the schools of many less developed countries have been those traditionally offered in European schools. They were imported into the curriculum of those nations when they were colonies of European powers. Textbooks, teaching materials of other sorts, and teaching methods have been imported with little, or insufficient, adaptation to the culture in which they are to be used. They refer to elements of foreign cultures, and picture people that may be almost totally unfamiliar to students, particularly those who live in rural areas. What is more, they are, in many countries, presented in a language that is not the common speech of the people. Even programs that have been developed for a culturally quite similar less developed country may have these faults, since dialects of the same language differ and the materials may reflect a way of life unknown to the students. Textbooks developed for use in London, Paris, or Chicago may show houses, furniture, electrical equipment, machinery, and foods unknown in the less developed rural environment. Or a type of agriculture, common in another less developed country, may be depicted that deals with different crops than the students know.

In addition, in less developed countries that have recently been colonies, the unwritten assumption of the educational system may have been that its products should be as much as possible like their foreign administrators. The schools may have been intended to train civil servants for a colonial administrative structure. A report of a French educational project in Mandoul, Chad says:[1]

> "The irrelevance of the programmes and methods of primary education to the problems of the rural world had turned the schools into machines for producing civil servants and unemployed. Despite the growth in the Chad's civil-service force (from 6,926 in 1962 to 11,188 in 1965), public administration could clearly not be regarded as a normal job outlet for all school leavers. Enrollments in the Mandoul Valley (19 percent according to the 1965-1977 BDPA socioeconomic survey; in fact 35 percent at present but with a far smaller percentage of girls than of boys) were on a large enough scale to keep adding to the group of idle school leavers, who were poorly integrated into their rural setting. In 1967, Mandoul was generating a yearly quota of 2,000 school leavers in this predicament."

It is no wonder, therefore, that motivation to continue in school may be low among both adults and children.

The best interests of the governments and citizens of less developed countries require that the education offered in the schools and nonformal instructional programs prepare students for useful participation in their society's processes. In most of these countries, demand for trained administrative and managerial personnel can be expected to increase, as well as demand for technologists of all sorts. At the lower end of the educational scale, literacy will become more and more necessary as mechanization of farming and industry proceeds. Social mobility, at a minimum in many of these countries, particularly for rural and lower class people, can be expected to increase.

On the other hand, the pace of social change in many less developed countries is such that job openings for trained people will be limited for some time. If a large number of such people cannot find jobs, social unrest and personal unhappiness can be predicted.

Ideally, therefore, the curricula offered should both provide people to fill positions in government, industry, and education and be relevant to people living in traditional rural environments.

19.2 Levels and subsystem or subsystems involved in this study. The levels are the organization (schools, educational systems, rural communities) and the society. The chief subsystem is the input transducer.

19.3 Existing relevant research. Projects designed to make education more suitable for the populations of certain less developed countries are relevant to this study. The "Mandoul" project, a rural education experiment in Chad, has been discussed in Section 12.3 above (see pages      to      ). The government of Senegal has also worked out plans for reform of the educational system of that country, its initial stages to be concerned with rural areas.[2] The report stresses the necessity of involving the people of rural communities in planning their own educational programs. This report stresses practical rather than academic training for many children who have completed the primary course in school. A pilot project began in 1972.

Another report, on adult education, by the French Delegation to the Development Assistance Committee of the Organization for Economic Co-Operation and Development, stresses the importance of avoiding excessive urban-rural polarization by directing development of small intermediate towns. The report says:[3] "...the rural exodus, or migration from country to "city" could be cut down by a systematic policy of urbanization and development in 'intermediate' areas. Small intermediate towns with proper social and cultural facilities would become halting points for rural migration. Being nearer to rural areas, these intermediate towns could at the same time provide local markets which would justify the farmers' work as well as creating new occupations (maintenance trades, market-gardeners, etc.) Moreover, the provision of socio-cultural facilities would itself create new jobs."

A further point in this report is the need to assist in the development of an "intermediate technology" which would adapt production methods to the degree of technical awareness in the local environment and permit the best use of resources and also inspire original economic creativeness. The report discusses, further, the need to incorporate literacy programs in national policy, the use of the peoples' own language for basic literacy programs, and the need for modern training for young farmers. The latter would include both practical and academic work. Finally, vocational training for adults and advanced training for skilled workers are envisioned. These would include training within firms as well as use of schools in the evenings or at other times when regular classes are not in session.

19.4 The research design. This project would be carried out in two communities in each of three developing countries, selected for their cultural differences from one another. The communities chosen, however, should be matched as closely as possible on population size, educational and social status of the people, and occupational characteristics. In each country one of the communities chosen would be urban, the other rural. It is suggested that the location of the project be in a part of a city with ready access to a rural region. Since the small rural community will probably have but one school, a single school of the urban community would be selected, preferably one which served a predominantly working-class area.

Phase I, one year. The project would begin with an exploration, with representatives of the community, of what they felt to be their needs for formal education of children and nonformal education of adults. Some questions would be:

- What is their perceived need for literacy?
- How much interest have they in work-study programs?
- What need is felt in each community for technical training?
- At what level of skill do they want training?

- What are their reactions to their housing, farming methods, social organization, and need for health and nutritional instruction?
- What are their attitudes toward the existing educational system, and its teachers and administrators?
- What religious or tribal customes that would affect acceptance of any educational plan?

Discussion leaders would become thoroughly familiar in advance with statistical information about employment opportunities, developmental plans for the region and for the country as a whole, and budgetary limitations. Community representatives should be helped to see the realities of the country's educational problems.

Such free discussions would permit the impressions of educational planners to be checked against the existing demand for particular sorts of educational programs. They would also facilitate acceptance of pro-programs.

Phase II, one year. This stage of the project would include the development, by the project directors, of alternate curricula suitable for the different sorts of communities with which they were working. This does not mean that every community in each country would have a specially developed educational system. Communities would, however, have some choice among a number of alternative programs.

Some considerations are:

- What would be the comparative cost of printing suitable textbooks and presenting content material over mass media?

- To what extent would work-study or apprentice programs fill the needs of the communities?
- What sort of agricultural instruction would be suited to the crops and farming methods of the country?
- Should some of the fundamental courses in nutrition, technical skills, health, and family life be designed so that they did not require prior literacy training of the adult students?
- To what extent would programs be interchangeable among the different age groups and different countries, with suitable language and cultural modifications?

These curricula would then be discussed with the communities involved, to obtain feedbacks on the basis of which adjustments would be made in them if necessary.

Phase III, one year. This last stage of the project would involve comparision of the educational goals and demands of the various communities in the different countries. The alternative curricula would also be compared. A final report on findings and practical effects of the study would be written. This project would recommend changes in the educational systems of the countries in which it was carried out. The curricula would be tested in the various sorts of communities in all three countries. After a suitable period, comparisons of literacy rates, unemployment rates, and other relevant variables could be made but these would not be a part of this project.

19.5 Staffing and scheduling. In each of the three countries involved there would be a national project director and an associate director, one an anthropologist informed about the culture of the area and the other an educator. One of the national project directors would also direct the overall project. In addition the team in each country would have three group workers, recruited locally, and a secretary, also recruited locally. The entire team in each case would work through Phases I and II, but the group workers would not be needed in Phase III. Each phase would last one year, for a total of three years.

19.6 Steps required to translate findings into operational use. This would be accomplished for the communities studied by the end of Phase III, since this work would elicit direct action in them. To extend any worthwhile findings to other communities would require reporting on the results to administrators and educators, in writings and by conferences and other meetings, as well as direct action educational programs in any new communities to which it was decided the findings might be extended.

19.7 Coordination with other research and development work. This proposed study is obviously closely related to Project 12 above. Sociological and cultural aspects of education investigated in this study are relevant to the development or any curricular materials developed for formal or nonformal education.

19.8 Professional expertise required. Anthropologists, educators, and group workers.

19.9 Estimated costs. For one country the staffing requirements over the three phases would total 15 man-years, or 45 man-years for the entire project in three countries. The resources needed, phase by phase, would be:

| | | | |
|---|---|---|---|
| 1. | Phase I, one year | 216 man-years | $ 432,000 |
| 2. | Phase II, one year | 216 man-years | 432,000 |
| 3. | Phase III, one year | 108 man-years | 216,000 |
| | TOTAL | 540 man-years | $1,080,000 |

19.10 Appropriate countries for project. Honduras, Laos, or Dahomey.

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1. French Delegation. The "Mandoul" project--a rural education experiment in Chad. Restricted information paper of Development Assistance Committee, Organization for Economic Cooperation and Development DAC (72) 47. September, 1972, Unpublished mimeograph.
2. French Delegation. Practical intermediate education in Senegal. Restricted information paper of Development Assistance Committee, Organization for Economic Cooperation and Development DAC (72) 48. September, 1972, Unpublished mimeograph.
3. French Delegation. Guidelines for aid for adult education in developing countries. Restricted information paper of Development Assistance Committee, Organization for Economic Cooperation and Development DAC (72) 50. September, 1972, Unpublished mimeograph.

## 20. Proposed Project 20, Priority B

## SOURCES OF ELECTRICAL POWER

This is an engineering study comparing the cost-effectiveness and practicality of alternate sources of electrical power for instructional technology in a specific less developed country.

20.1 Objectives. Most of the hardware for instructional purposes listed in Table 7 above depends on electrical power, usually either 110 volt, 60 cycle alternating current or 12 volt direct current. If such equipment is to be operated in rural areas of less developed countries, or even in some urban areas, a dependable source of inexpensive electrical power must be available. This power must be available in one of the two forms just mentioned, preferably 110 volt, 60 cycle, for other forms will require a converter or else a great deal of standard equipment cannot be used, and the necessary adjustments will add significantly to costs as well as to maintenance problems.

The major objective of this study is to determine for a specific educational system the best of several modes of generating and/or storing electrical energy to operate instructional hardware. A second objective is to determine whether it is more cost-effective to generate this electricity on a decentralized basis at every school or locality, or on a centralized basis, transporting storage batteries to every school periodically or alternatively transmitting the energy over a network of wires. A third objective is to discover whether system can manufacture and do maintenance and repair on the sources of electrical power which are best for it.

20.2 Levels and subsystem or subsystems involved in this study. The organization and the society levels. Chiefly the ingestor or matter-energy storage subsystem and the producer subsystem would be examined in this study.

20.3 Existing relevant research. Thousands or tens of thousands of research and development activities during the Nineteenth and Twentieth Centuries have been devoted to exhaustive theoretical investigations and practical trials of a wide range of alternative ways to generate and/or store electricity. It is now apparent that there are many practical and often inexpensive ways to do this. Some are more practical if large quantities of electricity are to be produced. Others are better for a small-scale operation. Each process is dependent on a source of power, and the aviilability of the different sources differs dramatically from one part of the world to another. This is an important factor to consider in determining what means of providing electricity for educational technology shall be used in a specific less developed country. Another important consideration is the adequacy of the national distributor subsystem, or transportation system. If land transport is poor and slow, if air transport is irregular or nonexistent, if storms or floods or ice and snow often block roads, a plan for recharging storage batteries centrally and delivering them to schools periodically will not work. Delivery of power by wires or local generation of power must take its place.

So far as we have been able to determine, no systematic analysis has ever been made of how specific a less developed country could go about developing a system for providing electrical power for instructional technology. The current literature on the state of the art of electrical engineering suggests that any country interested in this issue must investigate a good many possible energy sources and decide on at least one--perhaps several, depending on local conditions in various parts of the country. These energy sources should include:

Methane

Propane

Butane

Kerosene and other petroleum products

Water power from flowing rivers or dams

Steam power

Windmills

Solar power (particularly feasible for desert areas within 35 degrees north or south of the equator[1]).

Atomic power

Additional sources, especially relevant to less developed countries, are:

A thermocouple in a fireplace. flue, or chimney

Animal or plant fats or ails

A thermocouple in animal dung--e.g., cow or camel, watered to speed spontaneous combustion

Burning dung

There is practical experience and relevant literature on most if not all of these methods of generating electricity. Similarly there is much known and written about alternative ways of storing and transmitting electrical energy.

The staff of Project SACI in the State of Rio Grande do Norte in Brazil has made a study somewhat like the one proposed.[2] They decided to deliver 12-volt automobile batteries on a monthly basis to each school to provide power for TV and radio receivers. This is now being done.

20.4 The research design. The first phase of this study would be devoted to getting an accurate description of the present and projected future needs of the educational system for electricity. This would include a determination of just where the schools and other institutions that will use it now are or will be located. It would also include an accurate determination of what sources of electricity exist or will exist in the society at large which could be used to supply the educational system. Also the facts should be learned about the expertise available on electrical engineering and technology, the maintenance and repair facilities, the state of the society's distributor subsystem, and the likelihood that unguarded power equipment will be damaged or stolen by vandals (very likely in some parts of the world, constituting a major maintenance problem).

During this first phase a complete inventory of possible power sources for generating electricity should be made. Also a literature survey should be carried out to determine the best one or more power systems to employ in the light of the particular situation discovered.

The second phase would include a complete engineering design of a total electrical power delivery system to meet the national educational system's present and projected future needs. This should take into account the problems of delivering power over space from a central generator in that particular environment; the possibility of using a national power system; the problems of developing and installing local generators that will need a minimum of maintenance; the training of service personnel; and all other mechanical and human aspects of the total proposed system. Alternative systems should also be described.

The final phase would consist of the implementation, on a limited trial basis, of the power delivery system chosen by the appropriate officials of the less developed country. The cost-effectiveness of the system would be determined and, if it appeared satisfactory, plans would be made to extend it throughout the country.

20.5 Staffing and scheduling. A project director who is an electrical engineer and an associate director who is an expert in instructional technology hardware would be required. These would probably come from out of the country. An administrative assistant and a secretary from the host country would also be needed.

The schedule of the phases would have to be flexible, depending upon the ease of obtaining the necessary data in that particular country in Phase I and the speed with which governmental officials could select a system and necessary equipment and personnel could be obtained to implement the limited trial in Phase III. The following schedule would probably be reasonable:

Phase I, one year.

Phase II, six months.

Phase III, two years.

20.6 Steps required to translate findings into operational use. For the host country these are the procedures of Phase III outlined at the end of Section 20.4 above. For other less developed nations to profit from the study it should be reported in engineering and educational journals that are read internationally, and at appropriate conventions.

20.7 Coordination with other research and development work. Most of the projects we propose in this document involve use of hardware as prostheses in an educational system. Most of this hardware operates an electrical power. Provision of it as needed, by means like those described in this project discussion, is essential if the other projects are to succeed and their findings are to have practical effect.

20.8 Professional expertise required. Experts in electrical engineering, educational technology, and data analysis.

20.9 Estimated costs. A total of  man-years of labor will be required for this project assuming thqt all operational personnel involved will be paid by the host country and all equipment bought by it. The manpower and monetary costs of each phase and the total would be:

| | | |
|---|---|---|
| 1. Phase I, one year | 48 man-months | $ 96,000 |
| 2. Phase II, six months | 24 man-months | 48,000 |
| 3. Phase III, two years | 96 man-months | 192,000 |
| TOTAL | 168 man-months | $336,000 |

20.10 Appropriate countries for project. Thailand, Zaire, and Ecuador.

## References

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## 21. Proposed Project 21, Priority B.

## MAINTENANCE OF EDUCATIONAL EQUIPMENT

This is a study of the comparative cost-effectiveness of alternative modes of repair and maintenance for various sorts of instructional and communications equipment for formal and nonformal education in various less developed countries and climates.

21.1 Objectives. Unfortunately the hard problems of hardware repair and maintenance are rarely given enough emphasis or taken into consideration soon enough in the planning of programs by instructional technologists and educators. It may well be that standard models of instructional equipment are so poorly designed or manufactured for the needs of less developed countries that they must be rejected as impractical or too costly to maintain. It may be that their use would be feasible in cities and towns where repair shops are near but not in rural areas. It may be they are not suited for the extremes of climate found in many less developed countries--hot or cold, damp or dry. It may be that their electronic circuitry is so sophisticated that few if any in the country can repair it. It may be that replacement parts cannot be made locally and are difficult or impossible to obtain from abroad. It may be that transportation is so difficult or unreliable or slow in some parts of the country that any equipment breakdown seriously disrupts the students' learning experiences. These are major, not minor concerns. The danger is great that unrealistic and idealistic educational planners and innovators may plunge into some large and expensive educational experiment without giving due thought to them.

The objective of this project, therefore, is to analyze these design, manufacturing, and maintenance problems in the light of what can be learned about the experience of less developed countries in such matters. Specifically the study would attempt to answer such questions as:

- How can design and manufacture of instructional hardware be modified, if necessary, to produce equipment that is optimal for less developed countries?
- What are the most cost-effective trade-off's between local repair and maintenance of equipment versus transport of equipment to central repair shops?
- How should repairmen for instructional hardware be trained in less developed countries?

Answers to these questions may go a long way toward determining which instructional media are feasible for a country and which are not.

21.2 Levels and subsystem or subsystems involved in this study. The levels are the group, organization, and society. The chief subsystems are the distributor, which transports repairmen and equipment needing maintenance, and the producer, which manufactures equipment and spare parts, and repairs equipment.

21.3 Existing relevant research. A number of large-scale educational radio and TV systems in both established and less developed countries have had much experience in equipment maintenance and have developed procedures for it and some rough ideas of costs. This is true of NET and the State University of New York network in the United States and Project SACI in

By consulting with the host country's educational planners and other officials as to their long range objectives, they should discover as much as possible about their plans about using instructional technologies and expectations as to what benefits could accrue from their use. The investigators should determine what media they planned to use and perhaps at this stage suggest others they should consider.

With all the information they had acquired they should then begin to analyze the hardware maintenance and repair problems in that country of the proposed technological system. They should deal with such questions as:

- Is centralized or local repair and maintenance more cost-effective in this country or in particular regions of the country? How is a decision on this affected by local communication and transportation facilities?

- If repair and maintenance are to be decentralized, how will the local repairmen be trained? What will be the costs of the tools and repair equipments they must have?

- What improvements in design and manufacture of the hardware would make it more suitable for this less developed country? Should the electronic components be less sophisticated so they would be easier for semitrained or poorly equipped persons to maintain and repair?

- What is the likely engineering effectiveness of the various media in the host country? What are their likely percentages and frequencies of down time?

Brazil, for instance. Some large computer networks for education, like Project PLATO of the University of Illinois, the Pilot Medical Program of Ohio State University, and the MERIT program of Michigan State University, the University of Michigan, and Wayne State University, have comparable experience with hardware maintenance in relation to computer-aided and/or managed instruction. There appears, however, to be no published research on these matters.

### 21.4 The research design.

Phase I, six months. The director and associate director of the project, the only two professional personnel, will visit major centers in several countries which use instructional technology, to learn how they handle their hardware maintenance and repair problems. They should also visit the major manufacturers of such hardware, to learn about how they are built and should be maintained and repaired. They should take interest in many of the media listed in Table 7, but concentrate on (a) radio, (b) TV, (c) instructional use of computers, (d) audio cassettes and players, (e) video cassettes and recorders, and (f) slide and movie projectors. They should visit, among other countries, the United States, Great Britain, West Germany, Japan, the Ivory Coast, Colombia, El Salvador, and Brazil (particularly Project SACI in the State of Rio Grande do Norte).

Phase II, one year. The two investigators should learn as much as they can about the host country. They should pay particular attention to the geographical distribution of its schools and other educational institutions, urban and rural. They should learn about the climate or climates of the country, the road system and communications system.

- Will it be necessary to have duplicate equipment in case of breakdowns?
- Will spare parts be easy or hard to obtain?
- What are the trade-offs of the following costs?
  - Original equipment costs
  - Redesign costs
  - Spare parts costs
  - Duplicate equipment costs
  - Maintenance and repair labor costs
  - Transportation labor costs
  - Other transportation costs
  - Down-time costs (in student and teacher time as well as money)
  - Traditional teaching costs (with teachers or paraprofessionals)
- Which of the above costs need be paid in national and which in international currencies?
- How should repairmen be trained?

The investigators might use computer models or simulations of alternative educational systems to discover the optimal one in terms of maintenance and repair as well as other considerations.

Phase III, six months. After all these analyses a final report with specific recommendations should be prepared and submitted to the proper authorities of the host country.

21.5 Staffing and scheduling. The entire staff would consist of a director and an associate director (an electrical engineer and an instructional technologist), and a secretary. The schedule would be:

Phase I, six months.

Phase II, one year.

Phase III, six months.

21.6 Steps required to translate findings into operational use. Submission of the final report and discussion of it with officials. They might, of course, request the investigators to take further steps.

21.7 Coordination with other research and development work. Maintenance and repair are essential in all instructional systems that use hardware. Consequently this project is related to and should be coordinated with most or all of our proposed projects.

21.8 Professional expertise required. An electrical engineer and an instructional technologist. Few of the less developed countries would have citizens with the necessary expertise, so these would have to be foreigners. The secretary, of course, could and probably will come from the host country.

21.9 Costs.

| | | |
|---|---|---|
| 1. Phase I, six months. | 18 man-months | $ 36,000 |
| 2. Phase II, one year. | 36 man-months | 72,000 |
| 3. Phase III, six months. | 18 man-months | 36,000 |
| TOTAL | 72 man-months | $144,000 |
| Travel expense Phase I. | | 8,000 |
| GRAND TOTAL | | $152,000 |

21.10 Appropriate countries for project.

## 22. Proposed Project 22, Priority C

## TEACHER TRAINING WITH TV AND VIDEO TAPES

This is a pilot study for a nationwide teacher-training program using TV and video tape recordings in a less developed country.

22.1 Objectives. The objective of this project is to plan and carry out a pilot operation of a training program for teachers using TV primarily, rather than teachers in direct face-to-face contacts, to provide the instruction. Video tape recorders would be used to provide feedbacks in microteaching situations. This approach is novel because nowhere has an entire teacher training program based on instructional media been implemented and evaluated. A program of this sort with both radio and television is just beginning in Rio Grande do Norte, Brazil. However, the idea needs evaluation in other places. TV are proposed as instructional media.

Trainers of teachers have three important functions for the people they are training. First, they are a source of information on the various disciplines they are training people to teach. Second, they provide a role model of what an instructor does. And, third, they must act as counselors to the teachers in training as these people have their first opportunities to teach.

Because the training of people to manage the learning process, whether they are called teachers or not, is crucial to the success of an educational system, the problems associated with the training of instructors (or managers of the learning process) are critical. For example, in El Salvador the educational reform using television that is underway has as one of its basic activities the retraining and improved pretraining of teachers. This is a basic requirement for an increase in educational effectiveness, whether it be for an innovative media-based system or for the expansion of an existing educational system.

It is not hard to understand why the present training of teachers needs improvement. The average teacher-training institution--and its staff--in a less developed country is a place of low prestige, poor motivation, and second-class students. As in established countries, capable students prefer other institutions of higher learning. According to Coombs, the lack of first-rate trainers in teacher-training institutions "is the blistering rub in many countries."[1]

Outside the formal education system the problem is not much better. Agricultural extension workers and community health workers are neither the best-paid nor the most prestigious employees of the agricultural and health ministries in less developed countries. The people who train them, if they are trained to be educators at all, rely much more on transmitting the basic technical skills required for the job than on the human requirements for persuading people to alter their traditional life patterns. New skills are needed both by the trainers and by those they train if informal educational programs are to have an important impact.

Teacher training in less developed countries is often hampered by a shortage of capable instructors. In some such countries, many of the educators responsible for training teachers are themselves poorly trained but are still expected to give classroom instruction, supervise practice teaching, and provide individual guidance to teacher trainees.

The proposed program could capitalize on the strengths of the available instructors. They could continue and even expand their supervision and guidance activities while academic subject-matter and teaching of methods would be supplemented by information received by TV and video tape recordings.

22.2 Levels and subsystem or subsystems involved in this study. The levels of the organization and the society. The chief subsystem involved is the associator, where the actual training of teachers goes on.

22.3 Existing relevant research. Research on teacher training systems has been carried out on a large scale in the United States in the last few years. Some of the results indicate that most teachers in training can benefit from the use of microteaching techniques employing video tape recorders.[2]

The United States Office of Education funded 9 projects in 1968 to develop comprehensive models for training of elementary teachers.[3] These models are now completed and available from the Office of Education. They were not designed to deal with the problems of less developed countries but they are relevant to any teacher-training situation. Among the problems with which they are concerned are: the appropriate proportion of effort to devote to academic instruction on one hand and to professional training experience on the other; the relation of preservice to in-service training; problems of evaluation of trainees; staff requirements for [illegible] teacher-training program; and problems of program management.

22.4 The research design. This project requires intensive work in one less developed country. The country that is selected should already have some educational TV. Its officials responsible for education and communication must be committed to expanding the use of TV and other media in education. A need for improving quality of teaching should be recognized and a number of citizens of the host country should be capable of microteaching methods with audiovisual aids.

1. Phase I, two years. The first step is to find such a country and arrange to work with its educational administrators. Since the needs of each country are different, a teacher-training program must take account of the special educational requirements of the country for which it is designed. In each nation the training system in use will have special characteristics, the needs for teachers will vary, the stage of development of educational TV and its current use in education will be different. In addition, the country will have its own special cultural characteristics, political climate, and social structure that must be taken into account in designing a system. The country in which the project is carried out will also have specific requirements for numbers and professional attainments of teacher graduates.

After the country is selected and its needs determined, a planning team should work with representatives of the educational system of the country, talk with teachers and teacher trainers, and visit teacher-training schools. They should also study the communications facilities of the country, to determine what educational uses are feasible.

On the basis of intensive interviews with these representatives of the educational system, and applying research results and experimental findings from other places, they should then be able to plan the nationwide teacher-training systems they propose to implement. This plan would describe specific interactions of the various components of the system: teachers, trainees, communications personnel and facilities, and educational administrators. It should be specific about the courses and other training experiences to be offered, their sequence, and details of the use of TV, video tape recordings, and other media. It should be possible, on the basis of the plan, to determine the qualifications and training of the instructors: the relations among all components of the proposed teacher-training system: and the bases upon which trainees would be evaluated.

Then instructional materials for TV, along with coordinated student workbooks and teacher manuals, would be prepared. Situations in which the students would carry out microteaching practice using video tape recorders to provide feedbacks (see page 47 ) would be described. Also the tests and other evaluation instruments to be used would be prepared.

2. Phase II, two years. For two years the TV curriculum planned would be tried on at least 200 teachers in training. Another set of 200 trainees instructed by traditional means would be compared on comparable measures of progress.

3. Phase III, one year. During the third year a final report on the pilot project would be prepared. If the approach appeared to be significantly more cost-effective than previous practices, it would be recommended for expanded application.

22.5 Staffing and scheduling. The planning team for this project should consist of people from the country for which the project is carried out, along with consultants from an established nation experienced in curricular planning, research design, TV program production, and use of microteaching methods with video tape recorders, teacher training, test design, and data analyses. The full-time staff should be recruited at the beginning of Phase I and serve throughout the project. As indicated above the project would have three one-year phases.

22.6 Steps required to translate findings into operational use. If it should turn out that TV teacher training combined with video tape recording feedbacks in microteaching sessions is significantly more cost-effective than traditional teaching methods, the new procedures should certainly be used more widely. The best way to make this happen is to give the findings wide publicity and assist educators interested in using the procedures in planning for their implementation.

22.7 Coordination with other research and development work. Other educational uses of TV and video tape recorders of course are related to this one. The same equipment could be used for other programs thereby saving money.

22.8 Professional expertise required. Instructional technologist, educators specializing in teacher training, two curriculum planners and writers, two TV script writers, two TV producers, one developer, three secretaries, consultants who are specialists in microteaching, and educational uses of media.

22.9 Estimated costs. The total estimated manpower needed for the project, excluding operating personnel from the host country, is 32 man-years. Assuming the TV facilities are available, the costs would be:

| | | | |
|---|---|---|---|
| 1. | Phase I, two years | 180 man-months | $ 360,000 |
| 2. | Phase II, two years | 132 man-months | 264,000 |
| 3. | Phase III, one year | 72 man-months | 144,000 |
| | | Video tape equipment | 10,000 |
| | TOTAL | 384 man-months | $778,000 |

22.10 Appropriate countries for project. Uruguay, Singapore, and Nigeria.

## References

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## 23. Proposed Project 23, Priority C

## SCHEDULING OF LEARNING SESSIONS

This is a study of the comparative cost-effectiveness of various time schedules involving more or less intensive interaction of students in less developed countries with instructional materials.

23.1 Objectives. The primary objective of this study is to determine the most cost-effective scheduling of learning sessions of students of different ages, using instructional TV, instructional radio, or CAI. A second objective is to discover whether the course of learning is significantly different with each of three instructional media.

23.2 Levels and subsystem or subsystems involved in this study. The levels are the group (class), organization (school), and society (less developed country). Associator subsystem, the locus of learning in both formal and nonformal educational programs.

23.3 Existing relevant research. Comparative researches on the cost-effectiveness of different learning schedules of various instructional media have not been carried out. Decisions concerning media use and scheduling have generally been made on practical or *ad hoc* grounds.

Experimental researches on learning and retention by Ebbinghaus, Jost, Youtz, and Radossawljewitsch demonstrated that nonsense syllables and verbal materials are both learned better and remembered better if the practice sessions are distributed over several days rather than all given on one day.[1] The practical implication of this project is that optimal scheduling of a unit of instruction by the media extends over several days rather than being lumped in a single one.

23.4 The research design. Groups of adults and regular primary and secondary school classes will be assigned to one of four experimental conditions: (a) 50 minutes of instruction by one of the media five days a week, either with only students present or with a paraprofessional acting as monitor; (b) 100 minutes of instruction by one of the media five days a week under similar circumstances; (c) 20 minutes five days a week, with an additional 30 minutes taught by a trained teacher; and (d) 50 minutes of instruction by one of the media one day a week, the additional four days being taught by a qualified teacher. The subject-matter to be taught should be readily testable. English as a foreign language, and nutrition and health are suggested as content fields.

It is proposed that TV, radio, and CAI be used in Mexico, and that in addition TV be used in Cambodia and radio in Sierra Leone. Use of all three media in Mexico will control for contamination of media variables by cultural variables in the research design, which would exist if only one instructional medium were used in each country. This research design yields 3 categories of students x 4 learning conditions x 3 media, or 36 cells representing different variations in Mexico. At least 25 classes would hopefully be used in each cell, or a total of 900 classes. In Cambodia and Sierra Leone, since only one instructional medium would be employed, only 300 classes would be required unless more classes were desired in each cell of the research design. It is important to note that fewer schools than classrooms need be involved in the study since in a single school several classrooms could be used and the same rooms could be employed for nonformal education after regular school, in the afternoon or evening.

Costs would include the expenses of developing and producing programs and of transmitting them over the different media, as well as teachers' and paraprofessionals' training and salaries. Costs would perhaps best be calculated in terms of monetary units per student hour.

Effectiveness measures would include formative evaluation and summative evaluation at the beginning of the experimental period, monthly during it, at its end, and a year later. Tests would include measures of cognitive knowledge and of attitudes. Graduates' performance in the society would be measured a year later (see Project 1 above).

With these measures it would be possible to compare costs and effectiveness of the different media and various schedules for three levels of students in different countries.

23.5 Staffing and scheduling. A project director assisted by experts in curricular development, programming, testing, and data analysis would be required. Where possible, existing programs should be used with appropriate translation and adaptation. An initial period of one year would be needed for working out details of the study, recruiting local and foreign personnel, developing programs, selecting schools and classes, and setting up the experimental situations. Instruction under the experiment would go on for one school year. Data analysis could continue during the succeeding year and for 6 months after follow-up testing is finished. The total duration of the project, therefore, would be 3 1/2 years.

23.6 Steps required to translate findings into operational use. If the data obtained during the study show that learning is as cost-effective when one of the media is used alone as when media and instruction by teachers are combined, it would be desirable to move into this form of instruction as rapidly as would be consistent with protecting the positions of those teachers already at work in the system. If, however, learning is superior with some combination of an instructor and a medium, the combination that proved most cost-effective should be put into practice without delay. In all cases, the entire cost of delivering instruction should be considered.

23.7 Coordination with other research and development work. Findings of this study concerned with intensity of scheduling, or with any instructional medium or combination of a medium and an instructor, could be applied to any program in which the same instructional medium is used. This application should take into account differences found in this present project in grade level of the students, the culture, course content, type of medium, and mix of instruction by teachers face-to-face and through instructional media.

23.8 Professional expertise required. The study would require research managers; experts in research design and statistics; radio and TV engineers; programmers for radio, TV, and CAI; TV and radio actors or teachers; TV directors; clerks; and secretaries.

23.9 Estimated costs. The estimated amount of labor for the necessary specialists, who would probably come from a foreign country like the United States, over the 3 1/2 years of the project, would be a total of 26 man-years, 10 in Mexico and 8 each in Cambodia and Sierra Leone. In addition, 12 man-years of specialists and secretarial and clerical personnel would be required in Mexico and 8 each in Sierra Leone and Cambodia. In Mexico the first year the project team would be made up of the principal investigator (who would coordinate the entire project and also direct the Mexican portion of it), an expert in research design and statistics, a radio-TV engineer, and two media programmers. These would all probably come from a foreign country. In addition there would be three Mexican media directors, three actor-teachers, and a secretary. The team in Cambodia would consist of a research administrator, an expert in research design and statistics, and a media programmer, all from abroad. In addition, there would be a media director, an actor-teacher, and a secretary, all of whom would be citizens of the local country. A similar team would be used during the first year in Sierra Leone. For the next 2 1/2 years the team in each country would be reduced to the administrator, an expert in research design and statistics, a clerk, and a secretary.

The costs, then, would be as follows:

| | | | |
|---|---|---|---|
| 1. | Personnel recruitment, study design, and program development | 288 man-months | $ 576,000 |
| 2. | Implementation of experiment | 144 man-months | 288,000 |
| 3. | Data processing and follow-up | 144 man-months | 288,000 |
| 4. | Data analysis | 36 man-months | 72,000 |
| 5. | Report writing | 36 man-months | 72,000 |
| | TOTAL | 648 man-months | $1,296,000 |

23.10 Appropriate countries for project. Three very different less developed countries are suggested for this project--Mexico, Cambodia, and Sierra Leone. Mexico has the capacity to implement programs with all three media because of its size, state of development, and previous experience with instructional technology. Sierra Leone might not be able to afford TV but could afford radio. Since it is likely to receive much United States aid, Cambodia could probably afford TV. The problems arising in the use of instructional technologies in the three countries would quite likely differ greatly because their geographical locations, social organizations, cultural characteristics, and stages of development are markedly different. As a result their orientations to instructional media are likely to diverge also.

## Reference

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## 24. Proposed Project 24, Priority C

## TV VS. TRADITIONAL EDUCATION AS PREPARATIONS FOR LITERACY AND EIGHTH GRADE EQUIVALENCY TESTS

This is a comparison of the cost-effectiveness of nonformal TV instruction and traditional education in preparing students to pass literacy tests and eighth grade equivalency tests in less developed countries.

24.1 Objectives. The main objective of this project is to determine whether TV or traditional classroom experience is the method of choice for a less developed country that wants to increase adult literacy and improve the educational status of its population.

As development of business and industry proceed and countries whose populations have been predominantly rural and agricultural begin to become urbanized, it is important that literacy and educational levels in the population increase so that, when jobs become available, people are prepared to fill them. The basic skills involved are necessary for life in the modern world whatever a person's occupation may be.

Most less developed countries have adult literacy and adult education programs but in many countries little is known of the degree to which these are successful in fulfilling their primary objective of improving the lives of people by giving them usable command over language skills and the other basic subjects taught in these courses. It is crucial that the funds committed for adult education be used in the most cost-effective way. In order to determine this, proficiency tests of a large number of students and a certificate to those who passed. A testing program of this sort, if those who passed were given a certificate of proficiency, would motivate adults to do the necessary work to pass it.

After two years a sample of those who passed would be investigated to discover whether occupational level has been improved as suggested.

24.2 Levels and subsystem or subsystems involved in this study. The levels are the organization and the society. The subsystems are the transmitter, channel, and receiver components of the channel and net subsystems, and the associator subsystem.

24.3 Existing relevant research. A study in Brazil compared, on ability to pass the government's eighth grade equivalency test, known as the Madureza, students who had taken courses in private "cram" schools with those who had taken courses offered over TV stations in São Paulo and Recife.[1] The findings are relevant to this project.

The new TV courses are offered over a several month period. Inexpensive books, like comic books, coordinated with the instructional TV programs, issued weekly and are sold inexpensively at book stands and in some stores. Twice annually in recent years tens of thousands of adults take the Madureza. They often want the certificate for its value in getting a job or a better job, or a higher salary. Many jobs in Brazil are open only to people who have passed this examination.

The student pays a "cram" school about $200 in fees. This is, of course, a private cost. The cost of the TV program is a public cost. On a per-student basis, the TV program is much less expensive.

By having each person who took the Madureza indicate where and how he had prepared for the examination it was possible to identify those who had prepared in "cram" schools and those who had taken the instructional TV program. Slightly more than half the TV students passed the test, while slightly less than half of the "cram" school students passed. The cost-effectiveness ratio of the instructional TV program appears definitely to have been superior in this case.

24.4 The research design. This project would have to be carried out in a country which already had had an instructional TV program. If adult education courses were also included in this, the project could get under way more quickly. Also the nation's educational planners must be interested in beginning a program whereby a certificate, diploma, or degree that would be accepted as a job credential equivalent to a certain number of years of formal schooling would be given on the bases of a test alone. Then a project could be begun to determine the cost-effectiveness of alternative methods of education in improving literacy and providing primary education.

Phase I, two years. The initial steps in the research design would be to develop and produce TV instructional programs on literacy and eighth grade education. Coordinated tests of literacy and of proficiency in school subjects would also be written. A system would also be set up to broadcast the TV instruction and after that to administer the tests by which in centers throughout the country. A government-sponsored public relations and educational campaign would be necessary to acquaint the people at large with the plan to administer the tests and to give certificates of proficiency. If no national system of testing all school children at the end of the eighth grade existed, it could be instituted also, although this would not be essential to the project being proposed.

Phase II, one year. After two years' preparation and publicity, the TV programs would be broadcast throughout the selected country. Then both the literacy test and the eighth grade equivalency test would be given at the end of a school year, after both formal courses for children and for adults, as well as nonformal courses, had been completed. Examinees would be asked to indicate what kind of course they had taken to prepare for their test--formal education courses or instructional TV courses. Also they would be asked to state their age, how many years they had been enrolled in school, and other relevant facts.

The criterion of educational effectiveness, a summative evaluation, would simply be whether the student had passed or failed the examination. Cost measures would be the calculated costs per student of the preparatory formal courses and TV instruction, based on budgetary and administrative data on the two sorts of education.

From the students who passed the tests either of literacy or of eighth grade equivalence, then, a random sample of 2,000 would be drawn, 1,000 in each group. These would be surveyed to determine what jobs they held, if any, and their current annual incomes. A similar procedure would be carried out with 2,000 matched control engineers that did not pass the tests and another 2,000 that did not take the courses.

Phase III, one year. Two years after the end of Phase II the experimental and central examinees would again be surveyed to discover if completion of the educational programs and attainment of the literacy of proficiency certificates had had an appreciable effect upon their job classifications and annual incomes. This form of summative evaluation would concern the impact of the educational programs on the society, going beyond simple test performance.

Data would be analyzed to determine the cost-effectiveness of the formal and nonformal programs, including the improvements they brought about, if any, in the lives of the students. Cost-benefit analyses could be made by comparing the average cost per student of the two educational programs with the average change in income of those who passed the course with the controls who did not and the controls who did not take the course.

24.5 Staffing and scheduling. It is assumed that the host country would pay for all preparation of course materials and programs, broadcasting, and instruction, and testing. The project would require a project director, assistant director, and secretary. In addition, two experts in constructing tests of literacy and of attainment in school subjects would be required during Phase I. Four survey researchers would be needed during Phases II and III to prepare and conduct the survey of the samples of students and controls as well as the follow-up survey.

The schedule would be as follows:

1. Phase I, two years. Recruiting project personnel; planning the program; preparing TV programs on literacy and eighth grade education; and writing literacy and eighth grade equivalency tests.

2. Phase II, one year. Presenting traditional and nonformal TV courses and testing students who complete them. Writing of interim report on test outcomes.

3. Phase III, two years. Follow-up survey, data analysis, and writing of final report.

24.6 Steps required to translate findings into operational use. Two sorts of effects might come from this study. First, the results of the tests might seem sufficiently important to the educators of the host country that a regular system of national certification tests would be institutionalized. It would then be necessary to set up permanent machinery for administering and scoring them. Second, the findings might produce a shift in emphasis in the host country's educational policy toward the method of instruction which had proved most cost-effective, and this would require adjustments in the educational system.

24.7 Coordination with other research and development work. This project would need to be coordinated with the planning of formal and nonformal education of the host country involved. It would certainly be of interest to planners and educators in other countries, since in the last five years much interest has arisen in giving certification and credit for nonformal education.

24.8 Professional expertise required. Project staff members with knowledge of educational testing methods, design and carrying out of surveys, data analysis, and statistics would be needed, a total of 31 man-years.

24.9 Estimated costs.

| | | | |
|---|---|---|---|
| 1. | Phase I, two years | 120 man-months | $240,000 |
| 2. | Phase II, one year | 84 man-months | 168,000 |
| 3. | Phase III, two years | 168 man-months | 336,000 |
| | TOTAL | 372 man-months | $744,000 |

24.10 Appropriate countries for the project. El Salvador, Ivory Coast, Singapore, each of which has an instructional TV program.

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1. Personal communications from numerous Brazilian educators, 1972.

## 25. Proposed Project 25, Priority C

## INCREASING IMPACT OF NONFORMAL INSTRUCTIONAL TV

This is a study of how to make nonformal instructional TV programs more relevant and interesting so that rural students in less developed nations are motivated to learn and continue their educations.

25.1 Objectives. The objectives of this study are to determine the effectiveness of locally prepared and presented TV programs in increasing the impact of nationally televised informal educational TV programs to which they are directly related. The study would test the hypothesis that active participation by rural people, including the opportunity to see people they know in broadcasts and to hear local problems discussed, would act as feedback and reinforcement in their learning process and would increase their motivation to learn and to adopt the innovations suggested by the programs.

A continuing problem for nonformal educational programs designed to teach such practical subjects as public health, nutrition, or agricultural methods has been that the rural populations to which they were directed have made only little use of them. People in these areas tend to follow traditional behavioral models and to be slow to adopt innovations. They may see little relevance to their own lives in the course content and therefore find it of little interest.

25.2 Levels and subsystem or subsystems involved in this study. This project would concern the levels of the group (small groups of rural adults), the organization (the system which provides nonformal education), and the society (a less developed country). The subsystems concerned are the input transducer and the associator. The input transducer reports attitudes of students in the nonformal educational process, and these feedbacks are used to make the instruction of the associator subsystem more relevant and interesting.

25.3 Existing relevant research. An extensive literature in learning theory demonstrates that feedback and reinforcement are essential to the learning process.[1] Research also makes it clear that an individual's learning can be enhanced by group participation.[2] And studies of group behavior indicate that people change their opinions to conform with those of other group members.[3] This could be true in the larger social organization of the community as well as in a small group. When a group disagrees with him, it is common for a subject to change even a fairly obvious judgment he has made, such as one concerning the lengths of two lines which are close, but one of which is noticeably longer than the other.

Feedback from hearing one's self openly state an attitude appears to reinforce that attitude. For example, when a subject in a group told another member something which was contrary to his private opinion (i.e., that a boring task was interesting and fun), his private opinion changed to correspond more closely with his statement.[4]

A group which participates in planning a task is more likely to have high morale and productivity than one which is not involved in such planning.[5] Performance is better and attitudes are more favorable when a group carries out plans they develop themselves than when they work from plans prepared entirely by others.

Some relevant experience has been gained in less developed countries. Giving direct rewards to people who complete a program or conform with the recommendations of a program has not, for the most part, been highly successful in motivating learning. Some attempts at such rewards are the stipends given in poverty programs in the United States; transistor radios given to men who accept sterilization in India; and food or entertainment provided in conjunction with programs.

Experience with rural radio clubs is also relevant to this project. Both Niger and India have had successful clubs where local discussions have followed broadcasts. In Niger, program materials have been contributed by listeners. UNESCO is sponsoring a locally produced television club experiment in Senegal in which club members design their own programs and are assisted in producing them.

25.4 The research design. This study is planned to test the hypotheses that broadcasting motivates learning better:

- When examples are drawn from the local environment, community people participate in the programming and the broadcasting, and when the information very specifically relates to the day-to-day life of the community.
- When the programming reinforces each message through repetition.
- When coordinated printed materials are available as adjuncts to the broadcast and to help the listener evaluate his understanding of it.
- When there is feedback from students to the broadcaster.
- When there are concrete incentives to learning, such as access to jobs or services that were previously unobtainable.

The project can be carried out only in a less developed country in which rural areas have access to televised instructional programs and in which a network of local TV stations capable of initiating local programs exists. It is proposed that in one such nation 12 experimental communities and 12 controls be matched insofar as possible on social and economic variables such as population number, average income, occupations, educational attainments of adults, and access to television broadcasts.

The communities selected as controls would have their usual access to nonformal instructional TV programs. Both conditions would have available printed materials coordinated with the programs which would include periodic tests, similar to the madureza (8th grade equivalent test) materials in Brazil. The subject-matter of the experimental courses would be public health, nutrition, child care, or other courses considered by educators in the country to be important to improving the lives of rural people.

Prior to the initiation of the study, one or more government experts would visit all 24 communities to rate them on variables related to the course materials. If they were to deal with improved agricultural methods, a government agricultural expert armed with an interview schedule could visit, interview farmers, and observe both their attitudes and practices. If they were to deal with health, a public health nurse could interview people and observe the community. Relevant facts such as crop yields or infant morbidity could also be learned for the 24 communities.

In addition to the programs and printed materials used in the control communities, the experimental communities would receive reinforcement and feedback intended to increase their interest in the TV programs and to facilitate their learning and acceptance of the ideas presented. A group worker would make regular visits to these communities to organize activities related to the televised courses. These would include one or more of the following, depending upon the interests and capabilities of the people involved:

(a) Clubs or organized small groups which would discuss the content of the instructional programs at regular intervals, expressing opinions, relating relevant experiences, and bringing up questions. Some or all of these discussions could be taped for broadcast from the local station.

(b) Clubs or groups which would create programs relevant to the course material, such as short plays, songs, case studies, or opinion surveys. The most interesting of these would be selected for broadcast.

(c) A visiting government expert, such as a doctor, public health nurse, sanitary engineer, or agricultural expert, could hold discussions or question periods with leading citizens of the community in which the particular problems of the locality would be related to the content material of the course--such problems as special climatic conditions or insect pests. Also local superstitions or prejudices could be discussed at such sessions. Some of these sessions could be televised live in local studios or taped by portable TV tape recorders for later broadcast.

Feedback would be provided in these communities directly through information given in the local broadcasts as to the conditions in the community as compared to others in the country--their crop yields, for example, or the number of cases of certain diseases. Feedback is provided also when people hear themselves or those they know or respect expressing positive attitudes. Members of the community not in sympathy with the ideas embodied in the instructional TV programs would tend to bring their beliefs into conformity with those of their neighbors, often but not always supporting the position taken by the majority of the group. The group meetings would continue during the entire period of the course.

Evaluation of the results of the experiment, comparing experimental and control communities, would involve several measures:

(a) Periodic evaluations by the public health nurse or other expert, disclosing any change in the conditions or attitudes in the community.

(b) The amount of demand for printed course materials.

(c) The number of people completing the course, as shown by the number of tests taken.

(d) Objective indices such as decrease in morbidity or increase in crop yields.

25.5 Staffing and scheduling. It is assumed that the host country will be responsible for developing all courses and instructional materials and producing all the TV programs as well as operating the TV network and programs.

The director and associate director would appropriately be one an expert in instructional technology and the other in rural sociology, preferably of the host country. In addition two full-time group workers, one data analyst and statistician, one survey researcher, two secretaries, and two part-time interviewers and raters--one in agriculture and one in public health--would be needed. Probably all except the survey researcher could be nationals of the host country. The project staff proper would all serve for the entire two years.

The overall time for the entire project would be two years.

25.6 Steps required to translate findings into operational use. Results of this experiment could be used directly to increase the acceptance of particular programs which were considered to be of importance to the country as a whole or to certain regions. They could be used also in regions in which opposition to needed changes or innovations was a bar to their adoption.

25.7 Coordination with other research and development work. This would be relevant to attempts by less developed countries to overcome resistance to change or to increase the rate of acceptance of ideas by their people. It would also be relevant to other experiments on motivating learning of informal instructional programs. It would coordinate with studies of the effectiveness of TV as an educational medium.

25.8 Professional expertise required. Experts in instructional technology, rural sociology, group organization and dynamics, survey research, data analysis and statistics, agriculture, and public health.

25.9 Estimated costs.

| | | | |
|---|---|---|---|
| 1. | First year | 108 man-months | $216,000 |
| 2. | Second year | 108 man-months | 216,000 |
| | TOTAL | 216 man-months | $432,000 |

25.10 Appropriate countries for project. Colombia, Singapore, and the Philippines have instructional TV including local stations with capability of initiating their own programs and would be suitable for the project.

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## 26. Proposed Project 26, Priority C

## INSTRUCTIONAL TECHNOLOGY RETRIEVAL SYSTEM

This is an analysis of how a user-oriented information storage and retrieval system can be designed to assist educators in less developed countries to choose the appropriate instructional technology for their purposes.

26.1 Objectives. The chief objective of this study is to design and test a computerized data bank that would contain information about educational technology. This would be available to aid less developed and established countries in deciding what sort of instructional technologies would best meet their needs, and in choosing among alternative technologies.

Educational deciders of less developed countries have often been overwhelmed either by the enthusiasm of representatives of the American government for educational technological innovations or by the entrepreneurship of American salesmen.

With better access to information, educational decision makers could select among technologies more rationally, taking into account the needs of their countries and the constraints under which they operate. They would also benefit from reported experiences of other countries and from published research on educational technologies.

26.2 Levels and subsystem or subsystems involved in this study. The levels of the organization, the society, and the supranational system are involved. The decider and memory subsystems are the chief ones concerned, the decider of schools and school systems in less developed countries and of the entire country, as well as a component of the supranational memory.

26.3 Existing relevant research. The extensive literature on development of data banks and computerized information storage and retrieval systems is relevant here. This is well summarized in the large, up-to-date handbook by Hayes and Becker.[1] An imaginative yet realistic appraisal of the coming potentials for on-line, computerized information retrieval systems appears in Licklider's Libraries of the Future.[2] Brown, Miller, and Keenan in EDUNET have described how a national information processing network for education could operate.[3] All these books could be referred to during the planning phase of this project.

26.4 The research design. In Phase I of this research, a six-month planning period, a panel of advisors would be selected. This group would include representatives of manufacturers of hardware for educational technology, experts in the associated software, educational planners from developing countries, educational systems experts, and specialists in the organizing and operating of educational data banks or libraries like the one developed by Project INTREX at MIT.[4] The panelists would act as advisors in all stages of the project. They would meet twice a year during the three-year period of the project.

Two centers in the United States store and, on request, supply information on educational technology. The ERIC Clearinghouse on Educational Media and Technology at Stanford makes available all information it can collect about instructional hardware and software in the United States, answering any questions it can about such instructional aids. The Academy for Educational Development operates a limited information center funded by AID, which is devoted to collecting information about hardware and software abroad and making it available to less developed countries. These centers are manually operated and not computerized, but would be initial sources of material for the proposed data bank.

The information store in the bank should include basic facts about hardware such as its physical description--size, weight, and any other relevant facts; power requirements; source and availability of replacement parts; skills needed to operate it; and costs. It should include titles, abstracts, physical description (such as format and size) of software and also important facts like the languages used. The address at which the hardware and software can be obtained should be included. It is important also that a system of feedback be made part of the information system, so that educators who wish to do so can report to others their own experiences with the technologies they have used, including their opinions on their strengths and weaknesses and data concerning their cost-effectiveness. Research reports in the field of instructional technology would also be included.

Phase II, a one-year testing period, would begin by the rental of on-line time-shared computer services. Then the information listed above should be read into the computer memory. Access to the computer could be by mail or by remote teletype terminal over telephone lines or even by satellite, as the Brazilian Space Agency in São Jose dos Campos has demonstrated to be feasible. They operated a remote terminal on-line by satellite to the Medline system of the National Library of Medicine in the United States. During this phase of the project, various types of users would be asked to test the system, asking sample questions by terminal of the information store and reporting how satisfied they were with the responses given. By this means shortcomings in the operation could be corrected.

In Phase III, an 18-month period, the information storage and retrieval system would be made available to users throughout the world. Adjustments in the programming of the system and additions to the information store could be made continuously throughout this period.

A log would be kept of the number and content of the requests during this period and users would be asked to supply information as to whether the information had been of use and how they had made use of it.

26.5 Staffing and scheduling. The director and associate director should be experts in computers and their use in data banks. In addition, to assist them, they will need three computer programmers, a librarian, and two abstract writers to collect the inputs and create the data bank. An administrative assistant to answer correspondence and keep users informed about the mode of operation and two secretaries will also be needed. In addition, the advisory committee altogether will put in the equivalent of one man-year of activity annually. All these personnel will be needed throughout the three years required for the three phase of the project.

26.6 Steps required to translate findings into operational use. This system would be operational during Phase III and could be continued beyond the three-year period of the experiment if it appears practical, if the demand is sufficient, and if funding can be arranged. If fees were charged for services it might become self-supporting.

26.7 Coordination with other research and development work. The data contained in this data bank would be available to those involved in research and development work and educational operations, to supply information about research and operating systems. It would receive from manufacturers, software producers, research and development projects and educational institutions using instructional technology reports which would be stored in the memory and become available to other workers in the field anywhere in the world. Special emphasis would be given to the activities of less developed countries. This form of resource sharing should improve the quality of many of the other projects we are proposing.

26.8 Professional expertise required. This project would require a high level of professional skill in information storage and retrieval systems, computers, and instructional technology. Also the expertise of computer programmers, a librarian, and two abstracters would be required.

26.9 Estimated costs.

| | | | |
|---|---|---|---|
| 1. | Phase I, six months | 72 man-months | $ 144,000 |
| 2. | Phase II, one year | 144 man-months | 288,000 |
| 3. | Phase III, 1 1/2 years | 216 man-months | 512,000 |
| | Computer service rental and communication costs, for 3 years | | 200,000 |
| | TOTAL | 432 man-months | $1,144,000 |

26.10 Appropriate countries for project. This system would be designed and set up in the United States. Its services would be available to any other country which requested information.

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